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RAYMOND C. MOORE, *Editor*

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JOURNAL OF PALEONTOLOGY

JUNE 1930

ORIENTATION OF THE CARAPACES OF PALEOZOIC OSTRACODA

By J. H. BONNEMA
Groningen, Holland

In 1908 the well-known American paleontologists Ulrich and Bassler wrote: "The feature of the study of Paleozoic Ostracoda, about which the literature of the subject seems to show the greatest variability and uncertainty among authors, is the determination of which of the two ends of the carapace and valves is the anterior"; and this is still the case. Ulrich and Bassler (20, p. 280; 21, p. 283), who were joined by Kummerow (13, p. 411) still regard, in many species, as the anterior end what the present writer (3, p. 13; 4, p. 117; 5, p. 67; 6, p. 1091; 7, p. 1109; 8, p. 16) calls the posterior.

As this question is of the highest importance for purposes of the description and comparison of the various genera and species, and the writer is becoming more and more convinced inter alia by the study of the Ostracoda of the Cretaceous of South Limburg that his opinion is the right one, he will explain this once more.

In my opinion this question can adequately be solved only by comparing the Paleozoic Ostracoda, either directly or by means of younger fossil Ostracoda, with the living Ostracoda. Here, as in geology, the dictum holds good: that "The present is the key to the past." By applying this principle more difficult questions have been solved.

If it be asked in what respects the carapaces of Paleozoic Ostra-

coda, which alone have been preserved, can teach us something that may be used in comparing the Paleozoic Ostracoda with the living I think this is the case with:

1. the position of the two lateral eyes.
2. the position of the sexual organs.
3. the location of the places on the interior of the valves where the adductor is attached.
4. the outline of the carapace.
5. the manner of closing the carapaces or the difference in size of the two valves.

I. While studying the Ostracoda of the Kuckers formation (C2) of Esthonia I found that in *Primitia tolli* m. (3, p. 16) the carapace is very thin at the places where the valves have, on the exterior, a more or less distinct node (figs. 1, 2).

According to Zenker (25, p. 8) this is also the case with marine Ostracoda at the places where the two lateral eyes are located. Moreover Müller (16, p. 412) mentions that at the place, where the median eye is located the carapace sometimes is "mehr oder weniger stark grubenartig vertieft" and "uhrglasartig vorgewölbt". This justifies the conclusion that with the above-mentioned Ostracod these caveties served to hold the lateral eyes and that therefore the end which is nearest to the small tubercles is to be regarded as the anterior end of the carapace.

In precisely the same way Ulrich and Bassler (20, p. 280) in their first paper on this subject determined the anterior end in the case of the Leperditiidae. They assume that the two eye tubercles of *Leperditia* served for the location of the lateral eyes, and say that this is universally accepted by paleontologists. How far we are justified in assuming this has never been to my knowledge sufficiently examined. The presence of tubercles alone does not, in my opinion, prove much as these are sometimes present at other places also, as Barrande has already remarked (19, p. 7.) Much more importance is to be attributed to the fact that the carapace is thin at those places already pointed out by Schmidt (19, p. 7), and which is mentioned by him with regard to *Leperditia grandis* Schrenck. The conclusion of the two first mentioned investigators is also that the end nearest to the tubercles is to be regarded as the anterior end.

In their later treatment of this question no further use is made of the Leperditiidae. In the same paper they even state that this family should perhaps be considered as Phyllopoda rather than as Ostra-

coda (21, p. 276, 287) which opinion I find it very difficult to share.

I formerly made no use of *Leperditia* in determining the orientation of the carapace with Paleozoic Ostracoda as the tubercles of the *Leperditia*-species are more developed and more acute than in *Primitia tolli*. The practically entire absence of tubercles was the very thing that led me to prefer this Ostracod. Furthermore it agrees better in many respects (e. g. size of the carapace, relative size of the valves, and structure of the free edges of the valves) with the other Paleozoic Ostracoda than the *Leperditia*-species do.

Kummerow (13, p. 412) appears not to be acquainted with what I have found in *Primitia tolli*, although in the list of literature my paper on the Ostracoda of the Kuckers formation is mentioned. That in *Steusloffia* (*Strepula*) *linnarssoni* Kr. and in *Bollia minor* Kr. var. *kuckersiana* Bonnema and var, *robusta* Bonnema eyes are present at the places indicated by him I am not inclined to admit. These places appear to me to be too low for this. In *Steusloffia linnarssoni* the tubercle may have originated owing to the uniting of the two ridges.

II. In living Ostracoda the carapace of the females is sometimes much thicker in the posterior part than that of the male. This is for instance the case in the species of the genus *Cytherella*. This is not only a result of the stronger development of the genital apparatus, but is also due to the eggs being preserved here for a time (18, p. 41, pl. XVIII) (figs. 3, 4).

This now frequent strong development of one of the ends of the carapace is first met with in some individuals of the Silurian and Devonian genus *Poloniella* (=*Dizygopleura*) (22, p. 889; 23, p. 994) (figs. 5 and 6). Making use of what I have just recorded of some living Ostracoda, I think, as does Miss van Veen, that they should be considered to be the females, and that the thickened end should be regarded as the posterior end of the carapace.

It follows from this that we are justified in assuming that the orientation of the carapaces of *Kloedenella* (*Poloniella*) given by me (6, p. 1091; 7, p. 1109) is the right one, and that that which is assumed by Ulrich and Bassler (21, p. 284, f. 12 A, 12) is not the right (f. 7, 8).

If we give this Ostracod the orientation which they propose, then the anterior end would be strongly thickened, and it has never been found in a living Ostracod, that there are two kinds of individuals, of which the one differs from the other by the greater development of the anterior end.

III. When one studies the figures of the Ostracoda from the well-

known work of Müller on the Ostracoda of the Gulf of Naples (14), one finds that the places where the adductor is fastened to the interior of the valves are sometimes found on middle part of the carapace, generally on the anterior half and hardly ever on the posterior half.

While studying the Ordovician Ostracoda of the Kuckers formation of Esthonia, I found (3, p. 78) that the points of attachment of the adductor are generally to be found on the interior of the valves on the ridges, which correspond with the chief (median) furrow on the exterior.

Hence I consider that we have to place the carapaces of the Paleozoic Ostracoda in such a position that these median furrows, which are often the only ones, are on the anterior part of the carapace. This is also the case with the carapaces of *Primitia tolli, Leperditia grandis* and the two *Poloniella*-species, in the case of which it has already been laid down in the foregoing in another way, which end is to be regarded as the anterior end.

Ulrich and Bassler (21, p. 284) and Kummerow (13, p. 412) assume, in my opinion wrongly, that these furrows are found on the posterior part.

IV. More especially when studying the Ostracoda from the Cretaceous of South Limburg, my attention was drawn by the fact that the anterior part of the carapace is often much more developed than the posterior. In the figures in the work of Müller (14) on the Ostracoda of the Gulf of Naples it also strikes one that the carapaces are generally higher at the anterior end than at the posterior. This is quite different from what one would expect theoretically. Here too we see, what is well known to every one who has any knowledge of biology, that not everything is arranged adequately in nature. Went (24) has pointed this out so far as concerns plants. Abel (1, p. 12) has indicated on various occasions "fehlgeschlagene Anpassungen" in the animal kingdom, and Plate also (17, p. 112) devotes, in his "Abstammungslehre", a chapter to "Indifferente und unzweckmässige Anpassungen" the latter of which he calls "dysteleologische".

In my opinion it is therefore not permissible, when determining the orientation of the carapaces in Paleozoic Ostracoda, to take as the posterior end the end which, during movement in the water, has offered the greatest resistance, as Ulrich, Bassler and Kummerow do.

With this the location of the two brood pouches to which they attribute such a great importance in this regard, also loses its value in determining the orientation of the carapaces by means of them.

Perhaps the brood pouches were inconvenient to the Ostracoda

which possessed them, during motion in the water and possibly that is why they have disappeared in the Devonian (21, p. 292).

Even if we admit that the brood pouches have contained parts of the ovaries, which I do not think probable, it is dangerous to use their location in determining the orientation of the carapaces. For Müller (16, p. 416, f. 367) states that in *Strandesia strandesioides* G. W. Müller the testes extend over the entire length into the valves. Perhaps this has been also the case with the ovaries.

V. When one tries to find out from the literature on the living Ostracoda (e. g. 14 and 18), how the hinge lines lie in regard to each other, and how this is the case with the free edges when the carapace is closed, it is seen that little is to be found on this point. The reason is, of course, that zoologists are but little concerned with the characters of the carapace, and more with those of that part of the animal, which is within the carapace.

A favourable exception is Fassbinder (11, p. 4), who has studied this closely in some freshwater Ostracoda.

As a general rule we shall be able also to ascertain something from the relative size of the two valves about the manner in which the carapaces close, but when one of the valves projects beyond the ventral edge or beyond the dorsal edge the manner of closing may be otherwise than the relative size of the valves leads one to expect.

When one tries to find in the literature on living Ostracoda (e. g. 14, 15 and 18) how it is with the relative size of the two valves, then one finds sufficient data to warrant the conclusion that the left valve is generally the larger.

This result is in accordance with the fact that this is also the case with Tertiary (12) and Cretaceous (2) Ostracoda. Bosquet (9, p. 54 [44]) even mentions that it is only with the *Cytherella*-species that the right valve is larger than the left. Now this is no longer thought to be the case; with the Macrocyprinae, e.g., the same relation appears to exist.

If one endeavours to find how this is with Paleozoic Ostracoda then it is evident that here, too, the left valve is usually the larger, at any rate, when these Ostracoda are orientated as indicated by me. A very common manner of closing the carapace is then for the right valve to lie with its sharp free edge in the deep furrow in that of the left one. Not only does this hold good of the Ordovician Ostracoda of the Kuckers formation (C2), which I studied in my dissertation, and where it was found with the genera *Primitia, Ctenobolbina, Strepula, Tetradella, Ceratopsis* and *Ulrichia* (3, p. 79), but also of the Silurian

and Devonian species of *Beyrichia* (fig. 9) and *Poloniella*, which I studied later (4, p. 122; 5, p. 72; 6, p. 1089; 7, p. 1107; 8, p. 16). It would therefore appear that here, too, my manner of orientating the carapaces is probably the correct one.

This is further confirmed by the fact that this relation between the free edges of the two valves also occurs in *Primitia tolli* m. (fig. 2) and *Poloniella hieroglyphica* Kr., where in my opinion it has been shown with absolute certainty which end is to be regarded as the anterior one.

On the other hand it would seem that the fact that the right valves of the *Leperditia*-species are larger tells against this.

It is, however, possible that this is only apparently the case. For we may assume that the closing of the carapace here actually occurs in the same manner as is plainly shown in figs. 10 and 11. Here the right valve has become larger than the left one, because the inner margin of the furrow on the free edges of the left valve has become an inverted plate ("Umschlag"), so that the right valve projects beyond its ventral edge.

The structure of the free edges of the left valve in *Beyrichia tuberculata* (fig. 9) would then be a transition between that which occurs in *Primitia tolli* (fig. 2) and that of a *Leperditia*-species (fig. 11).

Leperditia grandis Schrenck (19, p. 10) with its small inverted plate of the left valve so that the right valve overlaps the left one only in the middle of the ventral edge, would in this respect agree most closely with the original structure. In agreement with this is the fact that, according to Schmidt (19, p. 11), Barrande is inclined to place it in the genus *Isochilina*. I imagine that he would certainly have done so, if the characters of this genus had at that time been stated to be as Ulrich and Bassler (21, p. 295) now give them. According to them in this genus the left valve also has an inverted plate ("Umschlag"), which formerly was not assumed (19, p. 9).

I think it therefore very probable that *Leperditia* descends from an *Isochilina*-species, and this genus from an Ostracod, which probably belonged to the genus *Leperditella* (21, p. 297), in which the sharp free edges of the right valve again lie in the furrow on the free edges of the left valve as is very often found in Ordovician and Silurian Ostracoda.

Isochilina and *Leperditia* would then be a side-branch of the Ostracoda, which became extinct in the Helderbergian of the lower Devonian (21, p. 293).

How the hinge lines of the two valves are joined is known in few Ordovician and Silurian Ostracoda. In *Primitia tolli* m. (4, p. 121, f. 2; 5, p. 71, f. 2) (fig. 2) and *Leperditia hisingeri* Schmidt (8, p. 16, pl. I, f. 7, 8) (fig. 10) the dorsal edges of the two valves simply lie against each other, while there is no particular arrangement for moving easily with respect to each other, and for keeping these edges in their places in the meantime.

In *Beyrichia tuberculata* Klöden (4, p. 122, f. 5, 6; 5, p. 72, f. 5, 6) (fig. 9), *Beyrichia jonesi* Boll var. *clavata* Kolmodin (4, p. 123, f. 7, 8; 5, p. 73, f. 7, 8) and *Poloniella hieroglyphica* Kr. (6, p. 1089, f. 5; 7, p. 1107, f. 5) I found that, with my manner of orientating the carapaces, the sharp dorsal edge of the left valve lies in the furrow on the dorsal edge of the right valve. It will probably be found later, that this junction of the dorsal edges is found in very many Ordovician and Silurian Ostracoda.

My theory as to the correct manner of orientating the carapaces of Paleozoic Ostracoda receives strong support from the fact that Fassbinder (11) found the same state of affairs with the dorsal edges of the carapaces of some fresh-water Ostracoda (fig. 2).

This support is furthermore increased by the fact that this is also the case with the free edges (fig. 2).

Both the dorsal and the free edges of the valves of the silurian *Beyrichia tuberculata* Klöden (fig. 9) are in essentials in entire agreement with those of the living *Cypris pubera* O. F. Fischer (11, p. 11, pl. I, f. 4, 5) (fig. 12) at any rate if we give to the carapace of *Beyrichia tuberculata* the position which I consider to be the correct one.

We see, therefore, that when we compare the Paleozoic Ostracoda with the living ones, all five manners indicate that the orientation of the carapaces given by me is the true one. Two of them even prove that it is the only possible one.

When we consider in which Paleozoic Ostracoda a different orientation is given to the carapace, we find that this is especially the case with those in which the lateral surfaces of the valves possess ridges separated by more or less perpendicular furrows, e.g., with the species of the genera *Tetradella, Ctenobolbina, Ceratopsis, Beyrichia, Poloniella,* etc. Unfortunately these cannot be compared by means of these ridges with living Ostracoda, because these latter, besides being generally smaller, never possess such ridges, but at best longitudinal ridges.

These furrows and ridges may, however, be used in comparing the Ordovician and Silurian Ostracoda with each other. If we do this

with a valve of *Primitia tolli* (fig. 1), in which it is known with certainty which end is to be regarded as the anterior end, and one of *Beyrichia protuberans* Boll (fig. 13), and then with this and one of *Beyrichia tuberculata* Klöden (fig. 14), in all three valves the free edges having the same structure, then I think that the median furrows, in which the muscle impressions are located, agree with one another, that further in the last mentioned Ostracod the oval middle node agrees with the node of *Primitia tolli;* the part of the valve with the two nodes with that part of the valve of *Primitia tolli* that is located before the node, and is therefore the anterior part, and that finally the part of the valve with the three lobated ridge with that part of *Primitia tolli* which is located behind the furrow and is therefore the posterior part of the valve.

When we compare a valve of *Primitia tolli* with one of a *Ctenobolbina, Tetradella, Ceratopsis* or *Poloniella*-species, all of which having the same structure of the free edges, then we find here much the same thing, except that the posterior part of the valve is divided by a vertical furrow into two parts.

The various Ordovician and Silurian Ostracoda come in this way into the position which we have found for them by comparing them with living ones.

From what I have now stated about this question, I can but conclude that everything indicates that the orientation given by me is the true one, and that we obtain this by locating the carapace in such a manner that 1 in both of the two valves the median furrow in which the muscle spot is located, lies on the anterior part, so that the ventral part of it curves more or less forward, 2 that the nodes next the median furrows lie on the anterior part of the carapace and 3 that the closing of the carapace occurs by laying the sharp free edges of the right valve in the furrow on the free edges of the left one, while probably the sharp dorsal edge of the left valve lies in the furrow on that of the right valve.

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EXPLANATIONS OF THE FIGURES

FIG. 1.—Left valve of *Primitia tolli* m. ×15.

2.—Transverse section of a carapace of *Primitia tolli* m., through the part of the lateral eyes, posterior view. ×13.

3.—At the left: carapace of a female of *Cytherella abyssorum* G. O. Sars, dorsal view. At the right: carapace of a male of *Cytherella abyssorum* G. O. Sars, dorsal view. (After Sars.)

4.—Left side of a female of *Cytherella abyssorum* G. O. Sars, with eggs. (After Sars.)

5.—Carapace of *Poloniella hieroglyphica* Kr. of a male, seen from the dorsal side. ×40.

6.—Carapace of *Poloniella hieroglyphica* Kr. of a female, seen from the dorsal side. ×40.

7.—Carapace of *Poloniella hieroglyphica* Kr., seen from the left side. ×40.

8.—A left valve of *Dizygopleura* (=*Poloniella*) *stosei* Ulrich and Bassler. × 20. (After Ulrich and Bassler.)

9.—Transverse section of a carapace of *Beyrichia tuberculata* Klöden, posterior view. ×20.

10.—Transverse section of a carapace of *Leperditia hisingeri* Schmidt, posterior view. ×2.

11.—Transverse section of the ventral part of a carapace of *Leperditia hisingeri* Schmidt, posterior view. ×7.

12.—Transverse section of the dorsal and the ventral part of a carapace of *Cypris pubera* O. F. Müller, posterior view.

13.—Left valve of *Beyrichia protuberans* Boll. ×10.

14.—Left valve of *Beyrichia tuberculata* Klöden. ×10.

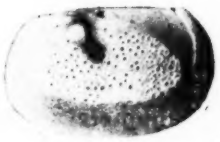

FIG. 1

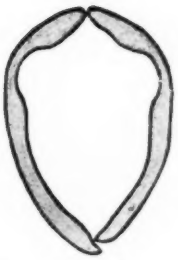

FIG. 2

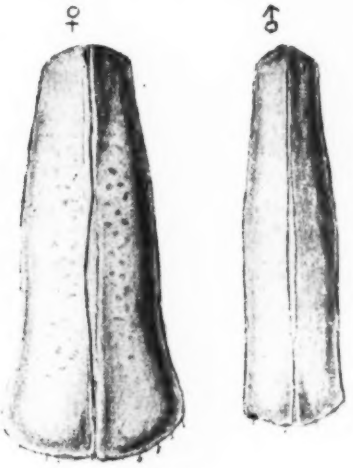

FIG. 3

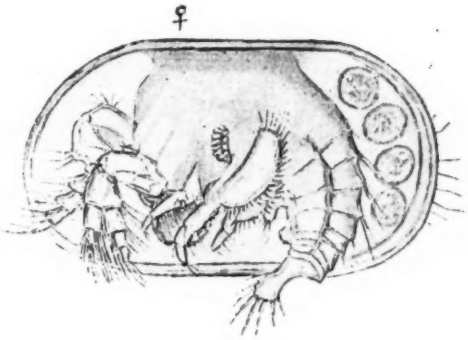

FIG. 4

FIG. 5

FIG. 6

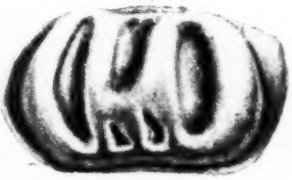

FIG. 7

FIG. 8

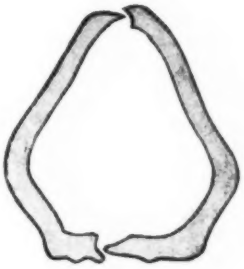

FIG. 9

FIG. 10

FIG. 11.

FIG. 12a

FIG. 12b.

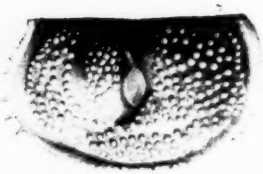

FIG. 13

FIG. 14

CONODONTS FROM THE DECORAH SHALE*

By CLINTON R. STAUFFER
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Minneapolis, Minnesota

The fossils commonly known as conodonts, are small crests of teeth, usually of microscopic size, occurring at various horizons throughout the Paleozoic. They have long been known to mark certain rather definite horizons, and often to occur in great abundance. Thus in the Cleveland shale, at Bedford, Ohio, they are found by the thousand in a thin horizon near the base of that formation. In fact they are so abundant that they are piled one on another like the fish bones, spines and teeth of the bone bed at the top of the Onondaga limestone in central Ohio. In the Caney shale of Oklahoma conodonts are occasionally almost equally abundant.

Broken fragments of conodonts have been washed from samples of the Decorah shale from time to time, but the best specimens discovered are those obtained on the campus of the University of Minnesota, in the Autumn of 1927, when the Auditorium shaft was put down through the Decorah shale, the Platteville limestone and the Glenwood beds to the heating tunnels in the St. Peter sandstone. About seven feet above the base of the Decorah shale, the shaft passed through a thin lens in the argillaceous beds, which was somewhat more calcareous than the enclosing sediment, and contained numerous fragmentary fossils. While these were being examined under the binocular microscope, a fine specimen of *Prioniodus* was discovered. A diligent search was then instituted with the result that about a dozen different species of conodonts, mostly in a fair state of preservation, were found and these form the basis of this study.

* This contribution made possible through the research funds of the Graduate School, University of Minnesota.

Associated with the conodonts are occasional thin scale-like fragments of the same amber color as the conodonts themselves. These are often marked by fine striae or, in some cases, by papillae. A few have the appearance of a beak and show growth lines. These latter may be small undetermined brachiopods. Some of the others may be the fragments of trilobites which are more or less numerous in this part of the formation. Still others suggest remnants of the body covering of small fish-like forms. Fragments of graptolites are also abundant, but they are characteristically black, and easily identified as such. Brachiopods, bryozoa, gastropods and ostracodes are likewise common, although most of them are fragmentary or crushed as a result of the compacting of the mud of which the shale is composed. The conodonts are unusually well preserved but they stick in the soft shales at all angles to the bedding and are not always easily freed from shale matrix. A number of fine specimens were lost in the effort to expose covered parts, while still others fell from the matrix without effort and some of these were lost. This conodont fauna should be an excellent marker and probably will be found at the same horizon over a large part of the area covered by the Decorah shale.

Pander, in his original descriptions, definitely included the conodonts among the fishes.[1] Zittel and others, however, regarded them as the teeth of chaetopod worms.[2] Although many writers on the subject have clung consistently to the classification of Pander, there has been a marked tendency on the part of paleontologists generally to follow Zittel and regard the conodonts as belonging to the Chaetopoda. Nevertheless, a more recent study of these difficult forms from the American Devonian and Mississippian[3] by Ulrich and Bassler places them among the primitive fishes and presents the case so clearly that few will now doubt the wisdom of this disposition of the group. Accordingly, they may have migrated over a much wider area than that covered by the Decorah shale, and their remains may thus be expected in any sediments of upper Black River or lower Trenton age.

The following descriptions of conodonts cover most of the species found. They are all from the same horizon and locality; viz. the lower Decorah shale in the Auditorium heating shaft on the campus of the University of Minnesota, although some of them were also

[1] C. H. Pander, Monographie der Fossilen Fische des Silurischen Systems der Russisch-Baltischen Gouvernements, St. Petersburg, 91 pp., 9 pls., 1856.
[2] J. V. Rohon und Carl von Zittel, Sitzungsberichte der mathematische-physikalischen Classe der k. Akademie Wissenschaften zu Münischen, vol. 16, pp. 108-136, 2 pls., 1886.
[3] E. O. Ulrich and R. S. Bassler, Proc. U. S. Nat. Mus., vol. 68, pp. 1-63, pls. 1-11, 1926.

identified in the shales of the same horizon at several places in St. Paul.

EUPRIONIODINA ROBUSTA, n. sp.
Plate 10, fig. 1

Base of tooth broad, scarcely bar like, arched and bearing one long large flattened cusp which comes to a rather abrupt point. Cusp slightly curved, and with sharp edges. Anterior downward projecting part of bar with three rather distantly spaced denticles. Posterior extension of bar with five sharp closely spaced denticles. Under high power (40 diam.) the surface of denticles and bar appear to be regularly pitted. Under still higher power (50 diam.) there appears to be a swelling at the base of the cusp on either side, but the appearance is somewhat elusive.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

DISTACODUS ARCUATUS, n. sp.
Plate 10, fig. 2

Tooth consisting of a single long tapering curved cusp which rises from a short base or bar. Cross section of cusp strongly convex on the outer and flattened to moderately convex on the inner side. The curvature is in two planes which gives the cusp a slight twist.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis, and at Stone Bridge, St. Paul.

PRIONIODUS? OBLIQUUS, n. sp.
Plate 10, figs. 3, 4

Tooth consisting of a long tapering stout cusp which rises obliquely from a thick flattened bar. There are three, or perhaps more, denticles occurring in a series along the margin of the bar and diverging but slightly from the direction of the denticle. The specimens of this species are fragmentary, but apparently distinct.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

LONCHODUS DENTATUS, n. sp.
Plate 10, figs. 5, 6 and 8

Five to six, perhaps more, robust cusps or denticles rising from an equally robust bar. Bar slightly curved on what appears to be the inside of jaw and cross sections of denticle highly convex on inner

side but flattened or moderately convex on outer side. Middle denticles nearly straight but the others curving slightly to right and left.

This species resembles *Lonchodus erectus* Smith (Natural History Society, Glasgow, Transactions, new series, vol. 7, part 3, p. 244, pl. 5, figs. 1, 2, 4, 5), but differs from it in its semi-flattened lateral denticles curving away from center, and in its more robust character.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

CORDYLODUS SERRATUS, n. sp.
Plate 10, fig. 7

Base thick, arched, terminating in a stout elongate cusp succeeded to the posterior by three to five denticles of which the middle one is the longest.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

SUBPRIONIODUS LATUS, n. sp.
Plate 10, fig. 9

Bar broad, notched, having five backwardly directed denticles on the upper margin. The first two denticles somewhat shorter than the

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EXPLANATION OF PLATE 10

All drawings are enlarged 30 diameters

FIG. 1.—*Euprioniodina robusta*, n. sp.
2.—*Distacodus arcuatus*, n. sp.
3, 4.—*Prioniodus? obliquus*, n. sp.
5, 6, 8.—*Lonchodus dentatus*, n. sp.
7.—*Cordylodus serratus*, n. sp.
9.—*Subprioniodus latus*, n. sp.
10.—*Euprioniodina futilis*, n. sp.
11.—*Prioniodus cultellatus*, n. sp.
12.—*Prioniodus aculeatus*, n. sp.
13.—*Prioniodus calcaratus*, n. sp.
14.—*Lonchodus*, sp.
15.—*Prioniodus cornutus*, n. sp.
16.—*Hibbardella?* sp.
17.—*Hibbardella? gracilis*, n. sp.
18.—*Prioniodina? macrodentus*, n. sp.
19.—*Prioniodus cristulus*, n. sp.
20.—*Belodus lineatus*, n. sp.
21.—*Lonchodus aequidentatus*, n. sp.

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rest. Denticles increase in sturdiness toward posterior end of bar. A slender curved cusp rises from the anterior end of the bar.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

EUPRIONIODINA FUTILIS, n. sp.
Plate 10, fig. 10

Base or bar short and stubby, perhaps broken. The large cusp rising from the center is slightly curved and is extended as a rounded ridge across the bar. One or two denticles on either side of cusp; others may have been broken off.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

PRIONIODUS CULTELLATUS, n. sp.
Plate 10, fig. 11

The tooth consists of a blade-like, but slightly twisted, cusp with nearly parallel sides for two-thirds of its length and then tapering to a point. This cusp is marked by two longitudinal furrows which define a rib-like axis. The cusp rises from the end of the bar and is extended below the same by nearly one-third of its total length. On the bar are first two short and then two long denticles.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

PRIONIODUS ACULEATUS, n. sp.
Plate 10, fig. 12

Bar broad and tapering anteriorally where it terminates in a long slender flattened cusp. On the bar, posterior to the cusp are three small sharp denticles succeeded posteriorally by two to three increasingly longer denticles which are nearly straight, but curve slightly backward. Others may exist increasing the series of denticles.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis, and at Stone Bridge, St. Paul.

PRIONIODUS CALCARATUS, n. sp.
Plate 10, fig. 13

Tooth consisting of a broad straight bar terminating anteriorally in a long slender tapering cusp curving slightly away from the bar at an angle slightly greater than ninety degrees. Cusp extended below

the bar at an acute angle. Six denticles pointing backward and increasing in size away from the cusp.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

LONCHODUS, sp.
Plate 10, fig. 14

A long robust bar with a series of five distantly spaced erect denticles, the middle of which is the longer. After the preliminary sketch was finished this specimen was accidentally brushed off of the shale slab and lost.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

PRIONIODUS CORNUTUS, n. sp.
Plate 10, fig. 15

Broad straight bar from the anterior end of which there arises a stout sharp cusp which meets it in an obtuse angle. Cusp slightly curved to the anterior and succeeded posteriorally by a series of four or five nearly vertical denticles.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

HIBBARDELLA? sp.
Plate 10, fig. 16

A stout curving cusp rising from the top of a broadly arched and massive bar. On either side of the cusp there are three or four denticles, of more or less equal size, which have their apices extending in the same direction as the cusp. After the preliminary sketch was made this specimen was also accidentally brushed off the shale slab and lost. Figures 14 and 16 are thus included to indicate the nature of some other conodonts belonging to this fauna. Owing to the uncertainty of their exact appearance no species name is assigned to either.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

HIBBARDELLA? GRACILIS, n. sp.
Plate 10, fig. 17

Tooth consisting of a long slender tapering cusp rising from the middle of a highly arched or angular bar. Two to three short denticles on either side of the main cusp.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

PRIONIODUS? MACRODENTUS, n. sp.
Plate 10, fig. 18

Base or bar very short and thick, perhaps broken. Cusp long and slender, apparently in the middle of a series of slightly diverging denticles, two are preserved on one side of the cusp and one on the other. This may not be a conodont, but it is composed of the same amber colored material of the other specimens and is believed to be one.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

PRIONIODUS CRISTULUS, n. sp.
Plate 10, fig. 19

Bar thick massive with elongate cusp at anterior end making almost a right angle. Four or five sharp denticles on upper edge of bar making obtuse angles with it. The front edge of cusp sharp or keeled.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

BELODUS LINEATUS, n. sp.
Plate 10, fig. 20

Bar long tapering terminating anteriorally in a stout tapering cusp which is twisted around so that its edges are almost at right angles to the edges of the four or more short denticles. These latter incline slightly forward as does the cusp.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

LONCHODUS AEQUIDENTATUS, n. sp.
Plate 10, fig. 21

Bar straight or nearly so. The series of cusps or denticles slender, nearly equal in size, about equally spaced along the bar, and wide apart. The cusps or denticles nearly erect but slightly inclined and curving backward. There are several specimens of this species, but they are fragmentary with only four denticles showing.

Occurrence.—Lower part of the Decorah shale, University of Minnesota campus, Minneapolis.

LOWER PENNSYLVANIAN FAUNAS FROM MICHIGAN

By W. A. KELLY*
Department of Geology, Michigan State College, East Lansing, Michigan

The area in Michigan underlain by Pennsylvanian deposits is entirely separated from deposits of the same period which outcrop in the neighboring states of Ohio, Indiana, and Illinois. It is impossible, therefore, to trace a horizon from one state to the other except through paleontologic criteria.

Hitherto, little work has been done on either the Pennsylvanian faunas or floras. Dr. David White has identified several small florules collected from coal mine workings, (1) and Dr. G. H. Girty identified some small faunules obtained from the same sources. (2) In 1926 a fossiliferous limestone member was noted near Grand Ledge, and a list of species provisionally identified was given. (3) Later in the same year, Mr. J. A. Waters collected some foraminifera from the Grand Ledge locality which were described by Dr. J. A. Cushman and Mr. Waters. (4)

STRATIGRAPHY

The maximum thickness of the Pennsylvanian strata of Michigan is more than 600 feet. The beds have been grouped into three formations, the Parma, the Saginaw, and the Woodville. Invertebrate fossils have been found only in the Saginaw formation and occur ordinarily in black shale and limestone beds. The thickest natural exposures in the state are found near Grand Ledge, where a composite section gives a thickness of about 150 feet. The most complete single section is given below.

* Published with the permission of the State Geologist.

Top	Feet	Inches
Shales containing nodules	6	0
Black, highly argillaceous limestone, with 6-inch shale parting, containing faunule characterized by Productidae	2	0
Dark, fissile shale with *Naiadites* faunule at base	2	0
Shale, containing thin sandstone lens which locally thickens to 10 feet. Foraminifera found in lower beds	17	0
Coal	1	6
Fine-grained sandstone, containing *Stigmaria* and irregular concretions, grading downward to sandy shale	9	6
Black, structureless, plastic shale containing *Lingula carbonaria* and foraminifera	3	0

This section was measured in the clay quarry of the Grand Ledge Face Brick Company, on the right bank of the Grand River, below the town of Grand Ledge, Michigan.

The Michigan Fauna

Our knowledge of the Pennsylvanian fauna of Michigan is based largely upon the single faunule obtained from the limestone ledge occurring in the section exposed near Grand Ledge. This faunule is largely a brachiopod one, although other classes of invertebrates are represented. Smaller faunules are present in at least three shale horizons beneath the limestone. Collections from other horizons and localities that have been studied indicate the presence of a few additional genera and species. A complete faunal list is given in the accompanying table. The list of fossils includes identifications made by Girty, and others by Cushman and Waters.

Faunal List	Michigan Localities									Grand Ledge Horizons		
	A	B	C	D	E	F	G	H	I	C	b	a
Glomospira pusilla (G)		*									x	
Ammobaculites compressa C.& W.		*									x	
Ammodiscus annularis (H B B)		*										x
Psammophis inversus S.		*										
Turritellella spirans C & W		*				x						x
Hyperammina bulbosa C & W		*										x
Endothyra bowmanni (P)		*										x
Trochamminina rudis C.& W.		*										x
Fusulinella ? sp.		*										
Lophophyllum profundum (E & H)		x								x		
Crinoid columnals		x								x		
Delocrinus ? sp.		x								x		
Archimedes sp		x								x		
Polypora sp.		x								x		
Rhombopora sp.		x								x		
Streblotrypa ? sp.		x								x		
Lingula carbonaria S.		x	x		?		x	?	x			x
Lingula Kanawhensis P	x											
Lingula umbonata C				x								
Orbiculoidea sp		x								x		
Crania modesta W & St J		x								x		
Schizophoria resupinoides (C.)		x		x						x		
Derbya crassa (M & H)		x								x		
Derbya sp		x		x						x		
Chonetes mesolobus N & P		x		x						x		
Chonetes sp "a"				x								
Chonetes sp "b"		x								x		
Lineproductus cora (d'O)		x		x	‡			‡		x		
Productus morrowensis M		x		x						x		
Productus saginawensis n sp		x								x		
Productus smithi n sp		x								x		
Marginifera muricata var missouriensis (G)		x		x	‡			‡		x		
Marginifera aff wabashensis N & P				x								
Spirifer boonensis S?		x								x		
Spirifer cameratus M.		x								x		
Spiriferina kentuckyensis (S.)		x								x		
Composita subtilita (H)		x		x						x		
Nuculopsis ventricosa (H)								‡				
Myalina sp.		x								x		
Naiadites elongata D		x										
Naiadites sp.						x						
Plagiostoma acosta (C)								‡				
Pleurophorus oblongus M.								‡				
Astartella compacta G.		x								x		
Pharkidonotus sp.		x										
Worthenia tabulata (C)		x								x		
Trepospira spheerulota (C)								‡				
Trepospira sp				x								
Sphaerodoma sp		x								x		
Meekospira cf. peracuta				x								
Igoceras sp		x								x		
Conularia sp.		x								x		
Orthoceras sp '		x								x		
Pseudorthoceras knoxense (Mc C)		x			‡					x		
Griffithides sp		x								x		

Table Showing Range and Distribution of Fossils in the Saginaw Formation

*-Identifications by Cushman and Waters - Ref # 4.
‡-Identifications by Girty - Ref # 2.

Analysis of Fauna

Foraminifera are at least present at two horizons of the Saginaw formation. Collections of shale samples which have been made from several horizons and localities within the state may show their more common occurrence.

Corals are represented by the single species *Lophophyllum profundum*. This is the common columella-bearing coral of the Pennsylvanian, its range extending through almost the entire system.

The presence of crinoids is indicated by a single lower brachial plate, which is referred to the genus *Delocrinus*, and by two types of crinoid columnals.

Bryozoans are sparsely and imperfectly represented. Only a few tiny fragments have been obtained. Specific identification is hazardous, since enough material for sectioning has not been found. A species of *Rhombopora*, which may be *R. nicklesi* or the young of *R. lepidodendroides*, has been recognized. The former species is characteristic of the Lower Pennsylvanian of Illinois; but *R. lepidodendroides* has a long geologic range.

Brachiopods are well represented in the Michigan faunas, in numbers both of species and individuals. The Atremata include three species of *Lingula*. *Lingula carbonaria* is a common Pennsylvanian species, which has been reported from Ohio and as far west as Colorado. *Lingula umbonata* is another common Pennsylvanian species, while *L. kanawhensis* is known from the Pottsville of Ohio and West Virginia.

The Neotremata are represented by an unidentified species of *Orbiculoidea*, and by *Crania modesta*, a common Pennsylvanian form.

The Protremata are the most abundant order of brachiopods. *Schizophoria resupinoides* (Cox) is one of the common forms. This brachiopod has been reported from Kentucky, Arkansas, Illinois, Pennsylvania and New Mexico, and has been doubtfully identified from West Virginia. The species, *S. resupinoides*, is closely related to *S. swallovi*, a Mississippian form, and is itself characteristic of the Pottsville. *Derbya crassa* is one of the most common Pennsylvanian forms in Michigan. It makes its first appearance in the Lowellville member of the Pottsville formation of Ohio, and has a long range in Kansas, Oklahoma, and Missouri. A second species of *Derbya* is present, but its specific identity is doubtful.

The Productidae are well represented. There are three species of *Chonetes*, one of which closely resembles *C. mesolobus* var. *euampygus*. This variety has been known up to now only from the Car-

bondale of Illinois, and from the Des Moines group of Missouri and Oklahoma. The affinities of the two remaining species of *Chonetes* are doubtful, and the species may be new. Four species are assigned to *Linoproductus* and *Productus*. *Linoproductus* (*Productus*) *cora* is a long-ranging form. *Productus saginawensis* and *P. smithi* are new, and *P. morrowensis* occurs in the lowest Pennsylvanian formation. A closely related form in Ohio which has been described by Morningstar (5) as *P. semireticulatus* var., ranges from the Boggs member to the Upper Mercer member of the Pottsville. The most common genus of the Michigan Productidae is *Marginifera*. The variety, *M. muricata* var. *missouriensis*, is found in several members of the Pottsville formation of Ohio, and is restricted to the Pottsville of Illinois. It occurs near the base of the Cherokee formation of Missouri, and one doubtful occurrence has been listed from near the top.

The Telotremata are present in the Saginaw formation of Michigan, but are not common there. One form is doubtfully referred to *Spiriferina kentuckyensis*. This is an inclusive and long range species, occurring at several horizons in the Pennsylvanian. *Spirifer boonensis*, on the other hand, has a limited geologic range, and in Illinois is confined to the Pottsville. It also occurs in the Pottsville of Ohio, where its range is given from the Boggs to the Black Flint member. The second species of *Spirifer* is *S. cameratus* sensu stricto. According to Dr. Dunbar (6) the species of *Spirifer* which possesses a marked grouping of plications, and which was formerly considered characteristic of *S. cameratus*, should be called *S. triplicatus*. In the restricted sense, *S. cameratus* is confined to the Pottsville. The genus *Composita*, because of imperfect preservation and the ubiquitous occurrence of its species, *C. subtilita*, demands no comment here.

Pelecypoda are represented by poorly preserved specimens for the most part. Among them *Nuculopsis ventricosa*, which was identified by Girty (2) from the Michigan mine in Bay County, occurs throughout the Pottsville of Ohio, and its range extends to beds of the Upper Pennsylvanian elsewhere. *Naiadites elongata* is found only in the lower Pottsville of Ohio. *Astartella compacta* is also restricted to the Pottsville of Ohio, and elsewhere, is found in the Cherokee formation of Missouri.

Worthenia tabulata is the most common form among the gastropoda. This form does not occur in the Pottsville of Ohio. Savage (7) states that it is restricted in Illinois to the McLeansboro formation, which is equivalent in age to the post-Allegheny. It has also been

identified, however, in the Morrow fauna. *Trepospira sphaerulata* was identified by Girty from the same locality in Michigan as *Nuculopsis ventricosa.* It is considered more typical of beds younger than the Pottsville.

The common cephalopod of the Saginaw formation is *Pseudorthoceras knoxense,* fragments of which are common in limestone beds of the Saginaw formation. *Pseudorthaceras knoxense* appears for the first time in the Lowellville member of the Pottsville of Ohio. In other states it is found at horizons younger than the Pottsville. Unidentified fragments of a second cephalopod, referred to *Orthoceras,* are not uncommon.

Trilobites are represented by a single pygidium, which is referred to *Griffithides.* It is well preserved, and bears a strong resemblance to the pygidium of *G. scitulus,* a species which has been reported from the Pottsville of West Virginia, but is ordinarily considered to be more characteristic of younger formations.

Correlation:

The original correlation of the coal bearing strata of Michigan with the Pottsville was made by Dr. David White, and was based on an examination of some florules obtained from coal mines of the state. (1) Dr. White's correlation is confirmed by the results of the present investigations.

In attempting to correlate the marine Pennsylvanian fauna of Michigan with those of other Pennsylvanian localities, one turns naturally to the neighboring states, Ohio, Indiana, and Illinois. A striking contrast is evident at first glance in the comparatively small size of the Michigan fauna. This is no doubt due in part to the very few outcrops of the Pennsylvanian beds in Michigan.

A comparison of the Michigan species with those listed by Dr. Morningstar (8) from the Pottsville formation of Ohio shows that, of the 18 species which are common, 40 per cent occur in the Lowellville, 55 per cent in the Boggs, 95 per cent in the lower Mercer, 60 per cent in the Upper Mercer, 70 per cent in the McArthur, and 55 per cent in the Black Flint members. A general correlation with the upper part of the Ohio Pottsville seems to be indicated. On the other hand the absence of the brachiopod species, *Schizophoria resupinoides,* and the gastropod genus, *Worthenia,* from the large Ohio fauna, although these forms are relatively common in Michigan, may imply that the Michigan fauna was not derived from the Ohio fauna. The presence of *S. resupinoides* and *Worthenia,* together with other fossils common to Michigan, in the Indiana-Illinois sections, does sug-

gest that the Michigan basin may have been connected with that of Indiana and Illinois.

The Michigan fauna contains several significant index species. Of these species, *Schizophoria resupinoides* is a typical Lower Pennsylvanian form. According to Dr. Marvin Weller **(9)** *S. resupinoides* has been collected from the cap rock of the Rock Island (No. 1) coal, and from an Indiana horizon of equivalent or nearly equivalent age. A single exception only has been found at a higher horizon. *Marginifera muricata* var. *missouriensis* is particularly characteristic of the upper half of the Ohio Pottsville, and is one of the fossils that is restricted to the Illinois Pottsville. **(7)** In Missouri it characterizes the lower part of the Cherokee shale, which Schuchert correlates with the Pottsville. *Marginifera* aff. *wabashensis* has been found in limestone fragments collected from New Haven Township, Shiawassee County, along with *Chonetes mesolobus*. The latter form is perhaps *C. mesolobus* var. *euampygus*, which is considered diagnostic of the Carbondale formation of Illinois. **(7)** The type of Productidae represented by *P. morrowensis* is only found in Lower Pennsylvanian faunas. Many forms related to, or at least similar to, it, have been described as varieties of *P. semireticulatus*. The type of this species is now restricted to the Mississippian, **(6)** so that our views on the geologic range of *P. semireticulatus* must be considerably modified. *Spirifer boonensis* is a species that is restricted to the lower Pennsylvanian horizons. Dr. Weller **(9)** states that it characterizes horizons in Indiana and Illinois which are probably nearly equivalent to the Lower Mercer limestone of Ohio.

A general review of the evidence regarding the age of the Saginaw formation indicates Lower Pennsylvanian. This conclusion is also confirmed by the absence of such forms as *Meekella striatocostata* and *Pugnax rockymontana*, which are considered diagnostic of the Upper Pennsylvanian.

DESCRIPTION OF COMMON AND SIGNIFICANT FOSSILS

PHYLUM COELENTERATA

Class ANTHOZOA

Genus LOPHOPHYLLUM Milne Edwards and Haime

LOPHOPHYLLUM PROFUNDUM (Milne Edwards and Haime)

Plate 11, figs. 1, 2

1851. *Cyathaxonia profunda* MILNE EDWARDS and HAIME, Mon. des Polyp. Foss., p. 323. (Carboniferous; Flint Ridge, Ohio.)

1915. *Lophophyllum profundum* GIRTY, U. S. Geol. Survey Bull. 544, p. 19, pl. II, figs. 1-6*a*. (Wewoka formation, Oklahoma.)

1922. *Lophophyllum profundum* MORNINGSTAR, Geol. Survey of Ohio, 4th ser., Bull. 25, p. 154, pl. VI, figs. 5, 6. (Pottsville formation, Ohio.)

Description.—Corallum simple, with slight curvature. Epitheca longitudinally striate, the striae corresponding with septa; growth wrinkles not prominent. Calyx deep, containing from 40 to 55 alternately long and short septa; interseptal tissue present only in small amounts. Pseudo-columella elliptical and compressed, and in early growth stages, merely a prolongation of the counter septum.

Remarks.—Girty (10) has pointed out that *L. profundum* may differ materially from the genotype of *Lophophyllum, L. konincki,* since the cardinal septum of the latter is produced to form the columella. This is the opposite of the case for *L. profundum*. Grabau (11) also states that the counter septum forms the columella. The Michigan specimens likewise show the derivation of the columella from the counter septum.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

PHYLUM MOLLUSCOIDEA

Class BRYOZOA

Genus RHOMBOPORA Meek

RHOMBOPORA, sp.

Description.—Zoarium represented only by broken stems, the diameter of which is slightly over 0.5 mm. Apertures arranged diagonally about stem; interspaces occupied by small granules, there being larger granules at apices of the rhombic apertures.

Remarks.—This species bears resemblance to *Rhombopora lepido-*

dendroides, but is smaller than the average of that species. It also bears resemblance to *R. nicklesi,* which is reported from the Lower Coal Measures of Illinois.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

Class BRACHIOPODA

Genus LINGULA Bruguiere

LINGULA CARBONARIA Shumard

1858. *Lingula carbonaria* SHUMARD, Trans. St. Louis Acad. Sci., vol. I, p. 215. (Coal Measures; Clark County, Mo.)

1922. *Lingula carbonaria* MORNINGSTAR, Geol. Survey of Ohio, 4th ser. Bull. 25, p. 166, pl. VII, fig. 1-3. (Pottsville formation, Ohio.)

Remarks.—This is the most common fossil of the Saginaw formation. In size, shape, proportions, and fine external markings, the Michigan specimens agree with plesiotypes of *L. carbonaria* Shumard, which were borrowed from the Ohio State Geological Survey, and described and figured by Dr. Morningstar.

Horizon and locality.—Saginaw formation; shale member below coal exposed in three clay quarries in the vicinity of Grand Ledge, Mich.; also in shale member stratigraphically above coal in quarry of American Vitrified Products Co., near Grand Ledge, Mich. Also shale member at base of quarry of New Corunna Brick Co., near Corunna, Mich.; in shale members penetrated by quarries and coal mines in Jackson, Shiawassee, Saginaw and Bay counties.

Genus CRANIA Retzius

CRANIA MODESTA White and St. John
Plate 11, fig. 18

1868. *Crania modesta* WHITE and ST. JOHN, Chicago Acad. Sci. Trans., vol. I, p. 118. (Upper Coal Measures; Fremont County, Iowa.)

1915. *Crania modesta* GIRTY, U. S. Geol. Surv. Bull. 544, p. 53, pl. VI, fig. 12-14. (Wewoka formation; Oklahoma.)

Remarks.—Several examples of a small *Crania* attached to crinoid columnals and to specimens of *Productus morrowensis* are known. The pedicle valve is concealed. Brachial valve flat with excentric apex; surface of host expressed on parasite.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

Genus SCHIZOPHORIA King

SCHIZOPHORIA RESUPINOIDES (Cox)
Plate 11, fig. 3

1856. *Orthis resupinoides* Cox, Kent. Geol. Survey, vol. III, p. 570, pl. IX, fig. 1.

Description.—Shell large, transversely ovate in outline, the hinge line straight and about one-half of the greatest width, the cardinal extremities rounded. The dimensions of a pedicle valve somewhat smaller than the average, are: length from beak to anterior margin 28 mm.; width of hinge 16 mm.; greatest width 31 mm. Pedicle valve slightly convex, the greatest convexity in the umbonal region, which is replaced anteriorly by a shallow sinus. Brachial valve highly convex, the surface curving sharply to the margin, the ratio of width to convexity in one specimen whose posterior half is well preserved, is 9 to 4. Internally the muscular scars are subovate in outline.

Surface of both valves marked by fine, regular, radiating costae, about 25 occupying the space of 4 millimeters, the intervening furrows less than the costae in width; summits of the costae are punctate.

Remarks.—This species is closely related to *Schizophoria* (*resupinata*) *swallovi*, a Mississippian form from which it differs chiefly in the possession of much finer costae. From *S. altirostis* it differs principally in size, *S. resupinoides* being a larger form.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich. Also in argillaceous limestone fragments collected from mine dump near mouth of Six-mile Creek, Shiawassee Co., Mich.

Genus DERBYA Waagen

DERBYA CRASSA (M. & H.)
Plate 11, fig. 4

1852. *Orthis umbraculum?* HALL, Stansb. Exped. Gt. Salt Lake, p. 412, pl. 3, fig. 6. (Carboniferous; Missouri River, above Ft. Leavenworth, Kan.)

1858. *Orthisina crassa* MEEK and HAYDEN, Acad. Nat. Sci. Philadelphia Proc., p. 261. (Coal Measures; Leavenworth, Kansas.)

1915. *Derbya crassa* GIRTY, U. S. Geol. Survey Bull. 544, p. 55, pl. VII, fig. 1. (Wewoka formation; Wewoka and Coalgate quadrangles, Okla.)

Remarks.—The common Pennsylvanian species, *Derbya crassa*, has been made to include a large number of subplano-convex shells, whose proportions and size vary considerably. Essential characters include the possession of a raised, and sometimes twisted, pointed

beak, and strong costae alternating with one or more weaker costae. The specimens obtained from the Michigan rocks are usually very poorly preserved, but the few well preserved specimens which have been found, fall within the limits of *D. crassa.*

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

DERBYA, sp.

Remarks.—Imperfectly preserved examples of a species of *Derbya* possessing a sinuate brachial valve are not uncommon in the Saginaw formation. It differs from the more common form, *D. crassa,* not only in this feature, but also in the greater convexity of both the brachial and pedicle valves.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich. Also in argillaceous limestone fragments collected from mine dump near mouth of Six-mile Creek, Shiawassee Co., Mich.

Genus CHONETES Fischer

CHONETES MESOLOBUS Norwood and Pratten

1855. *Chonetes mesolobus* NORWOOD and PRATTEN, Journ. Acad. Nat. Sci. Phil. 2nd Ser., vol. 3, p. 27, pl. 2, fig. 7 *a-c.* (Coal Measures; Belleville, Illinois; Charboniere, Missouri.)

Remarks.—A single specimen of this characteristic species has been collected from Michigan strata. It is smaller than the average, has ill-defined striae, and may be closely related to *C. mesolobus* var. *euampygus.*

Horizon and locality.—Saginaw formation; highly pyritized, argillaceous limestone fragment from New Haven township, Shiawassee Co., probably from mine in bed of Six-mile Creek.

CHONETES, sp. "a"
Plate 11, fig. 5

Remarks.—The common species of *Chonetes* found in the Saginaw formation bears a general resemblance to *C. granulifer.* It is usually much smaller than *C. granulifer,* and lacks a true sinus. In the character of the flat, ill-defined mesial depression, the Michigan species resembles *C. carbonifera* from the Carboniferous of China. The Michigan species may also be conspecific with the Ohio representatives of *C. choteauensis,* although it appears to be far removed from *C. choteauensis* of the Morrow fauna. Homeotypes of this species

were borrowed for comparative purposes from the Walker Museum.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich. Also in argillaceous limestone fragments collected from mine dump near mouth of Six-mile Creek, Shiawassee Co., Mich.

Genus LINOPRODUCTUS Chao

LINOPRODUCTUS CORA (d'Orbigny)

1842. *Productus cora* D'ORBIGNY, Voyage dans l'Amérique meridionale, PALEONTOLOGY, vol. 3, pt. 4, p. 55.

1844. *Productus cora* WHITE, Indiana Dept. Geology and Nat. Hist. 13th Ann. Rept., pt. 2, p. 126, pl. 26, figs. 1-3. (Coal Measures of Indiana.)

1922. *Productus cora* MORNINGSTAR, Geol. Survey of Ohio, 4th ser., Bull. 25, p. 180, pl. VIII, fig. 1-3. (Middle and upper Pottsville formation, Ohio.)

Description.—Shell longer than wide. Pedicle valve convex, and ornamented with fine, flexuose striae, 8 to 10 of which occupy the space of 5 mm. Concentric ribbing prominent near auriculations, but absent on umbo. Spine bases few. Brachial valve not observed.

Remarks.—This species is rarely well-preserved. It is usually found in a crushed and flattened condition, which gives a distorted outline to the shell. Long, slender, detached spines associated with this brachiopod are common. It clearly belongs to the "lineati" group, and the characteristic ornamentation of this species makes the identification comparatively certain. The species, *Productus cora,* has recently been made by Chao (12) the genotype of *Linoproductus.*

Horizon and locality.—Saginaw formation; argillaceous limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich. Also in argillaceous limestone exposed in old mine shaft near mouth of Six-mile Creek, Shiawassee Co.; limestone horizons in Verne Mine, Saginaw County, and Michigan Mine, Bay County.

PRODUCTUS MORROWENSIS Mather

Plate 11, figs. 8, 9

1915. *Productus morrowensis* MATHER, Bull. Den. Univ., vol. XVIII, p. 152, pl. 10, figs. 1-4. (Hale formation, Arkansas and Oklahoma; Morrow formation.)

Description.—Shell wider than long, a specimen of average size having length 20 mm., width 42 mm., thickness 17 mm. Pedicle valve possessing a broad shallow medial depression. Posterior half ornamented with strong concentric ribs and radial costae, about 8 of which occupy the space of 5 mm. near the edge of the visceral area;

anterior half without concentric ribbing. Scattered spines are present over most of the shell, but a prominent row of large spines is situated on umbonal flank, and a second row close to, but slightly oblique to the hinge margin. Brachial valve unknown.

Remarks.—This form belongs to the "semireticulate" group, but cannot be classed as a variety of *P. semireticulatus*, since according to Dunbar (6) the type of that species is confined to the Mississippian, and forms ordinarily assigned to that species, belong to a different group. It bears a very strong resemblance to the form described by Morningstar as *P. semireticulatus* var., but differs in the possession of two rows of spines, which also characterize *P. morrowensis*. In form and general ornamentation it also resembles *P. semireticulatus* var. *hermosanus* Girty, but has apparently, a much finer ornamentation.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

PRODUCTUS SAGINAWENSIS, n. sp.
Plate 11, figs, 10, 11

Description.—Shell of medium size, the hinge less than the greatest width. The dimensions of a partially deformed pedicle valve are: length from umbonal region to anterior margin 26 mm., width of valve 30 mm., convexity 11 mm. Pedicle valve moderately convex, the surface curving abruptly from the umbo to the cardinal margin, but more gradually to the lateral and anterior margins; the median portion of the valve slightly depressed. Surface of valve covered by discontinuous radiating costae, about 6 of which occupy the space of 5 mm.; crossing the costae upon the posterior part of the valve are fainter concentric markings, which gives an imperfect semireticulate ornamentation; spine bases numerous, and springing obliquely from costae, the costae often ending at the larger spines. Entire surface covered by very fine concentric markings.

Brachial valve flat over the visceral area and curving downward abruptly in anterior and lateral directions. Surface marked in manner similar to pedicle valve. Internally the cardinal process is short and bifid; from its base two ridges extend anteriorly but a short distance, and a third ridge rises and extends as a septum to the edge of the visceral area; lateral ridges extend towards cardinal extremities.

Remarks.—In its external appearance *Productus saginawensis* bears a resemblance to some forms which have been identified as *Juresania* (*Pustula*) *nebraskensis*, and it was provisionally identi-

EXPLANATION OF PLATE 11

FIGS. 1, 2.—*Lophophyllum profundum* (Milne Edwards and Haime). Saginaw formation, limestone member; shale quarry near Grand Ledge. Fig. 1, a specimen of average size. Fig. 2, early part of calyx ground down to show relation of septum to columella.

3.—*Schizophoria resupinoides* (Cox). Saginaw formation, limestone member; shale quarry near Grand Ledge. Pedicle valve of somewhat smaller than average size.

4.—*Derbya crassa* (Meek and Hayden). Saginaw formation, limestone member; shale quarry near Grand Ledge. Pedicle valve showing character of ornamentation.

5.—*Chonetes*, sp. "a". Saginaw formation, limestone member; shale quarry near Grand Ledge. Pedicle valve of average size showing broad ill-defined sinus.

6, 7.—*Marginifera muricata* var. *missouriensis* Girty. Saginaw formation, limestone member; shale quarry near Grand Ledge. Fig. 6, pedicle valve, ×1½. Fig. 7, internal view of brachial valve showing weakly developed marginal ridge, ×1½.

8, 9.—*Productus morrowensis* Mather. Saginaw formation, limestone member; shale quarry near Grand Ledge. Fig. 8, pedicle valve showing the "semireticulate" character of the posterior part of valve in contrast with the costate character of the anterior. Fig. 9, posterior view of fig. 8, showing the convexity and sinuate character of the valve.

10, 11.—*Productus saginawensis*, n. sp. Saginaw formation, limestone member; shale quarry near Grand Ledge. Fig. 10, pedicle valve, slightly enlarged, of the holotype. Fig. 11, internal view of the brachial valve of a paratype, showing the relation of the median septum to the two short ridges anterior to the cardinal process.

12.—*Naiadites elongata* Dawson. Saginaw formation, shale bed below the limestone member; shale quarry near Grand Ledge. View of left valve showing oblique shape and the fine concentric ornamentation.

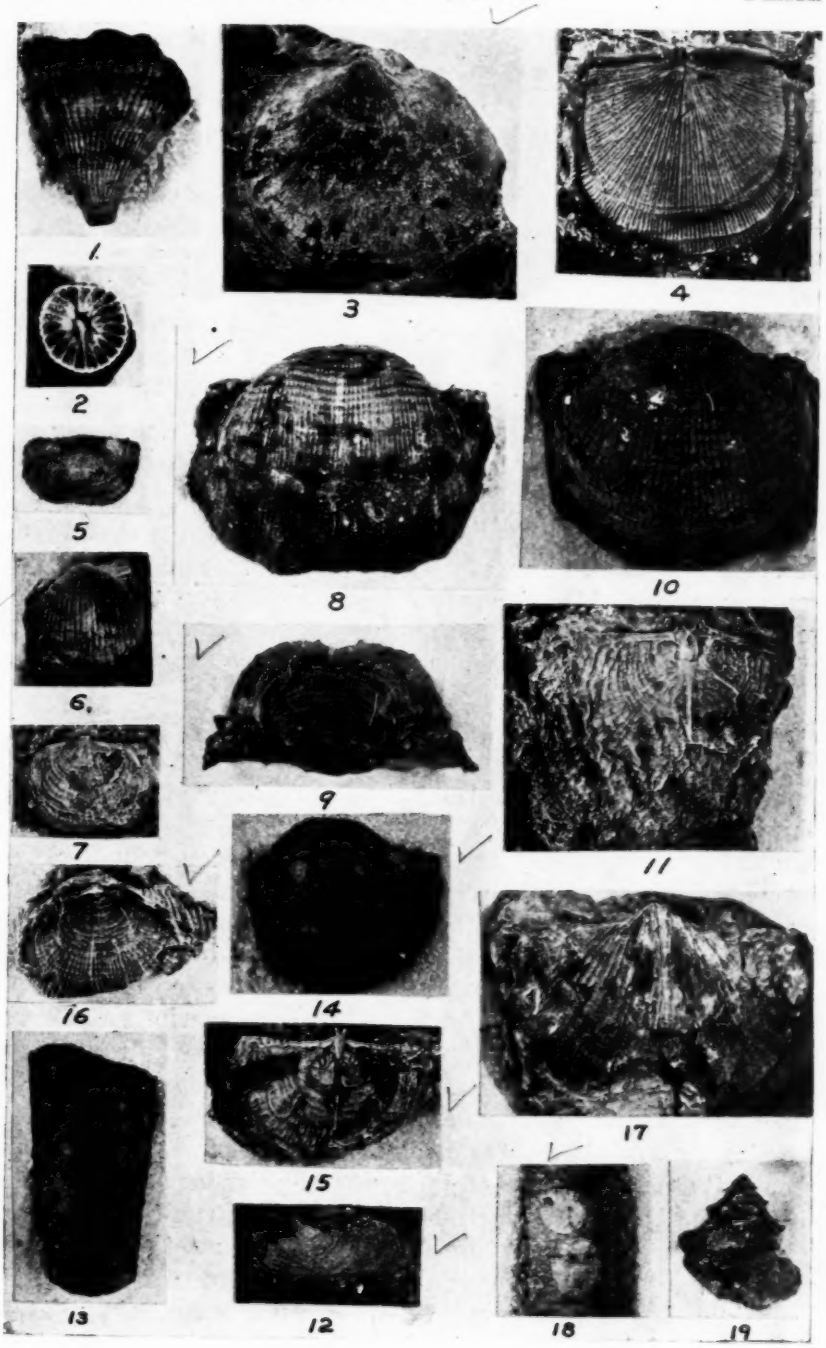
13.—*Pseudorthoceras knoxense* (McChesney). Saginaw formation, limestone member; shale quarry near Grand Ledge. Section through center of specimen showing the expanding siphuncle, and the method of filling prevailing in this genus.

14, 15, 16.—*Productus smithi*, n. sp. Saginaw formation, limestone member; shale quarry near Grand Ledge. Fig. 14, pedicle valve of the holotype. Fig. 15, internal view of brachial valve, a paratype, showing the bifid cardinal process, muscle scars, and brachial supports. Fig. 16, view of a paratype with a portion of the shell substance broken away to show the impression of the brachial valve.

17.—*Spirifer cameratus* Morton. Saginaw formation, limestone member; shale quarry near Grand Ledge. Pedicle valve of partly exfoliated specimen.

18.—*Crania modesta* White and St. John. Saginaw formation, limestone member; shale quarry near Grand Ledge. Brachial valves attached to crinoid column.

19.—*Worthenia tabulata* (Conrad). Saginaw formation limestone member; shale quarry near Grand Ledge. Apertural view of specimen below the average in size.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fied as *Pustula nebraskensis* by the writer in an early paper on the fauna of Grand Ledge. (3) It differs from this form chiefly in its lesser convexity and in its more appressed spines. From *Pustula symmetrica* it differs chiefly in the less pronounced character of the concentric ribbing. This species is assigned to the genus *Productus*, rather than to *Pustula* or *Juresania*, because the body cavity does not increase uniformly in size. (12)

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

Present location.—The holotype (18Sf18.1) and paratypes (18Sf18.2 to 18Sf18.3) are in the collections of Michigan State College, East Lansing, Mich. The specific name is taken from the name of the formation in which the fossil occurs.

PRODUCTUS SMITHI, n. sp.
Plate 11, figs. 14, 15, 16

Description.—Shell thin, of medium size, longer than wide, the hinge-line shorter than the greatest width below, the cardinal extremities angular. The measurements of a somewhat imperfect specimen are: length along curved surface 43 mm., length from hinge line to anterior margin, 17 mm., convexity, 14 mm. Pedicle valve gibbous, the greatest convexity near the middle. Lateral slopes deflected abruptly, postero-lateral slopes curving more gently to form rather marked auriculations; the beak projecting slightly beyond the hinge line. Surface marked by spines, costae and concentric ribs. The anterior three-fifths of the valve covered by fine, rounded costae, about 9 of which occupy the space of 5 mm. at the end of the visceral area: distinct concentric ribs, but no costae occur upon the posterior fifth of the valve; the intervening area covered both by costae and ribs; fine concentric lines of growth are present over the entire surface. Spine bases arranged quincuncially over posterior area, but not in a markedly regular manner over anterior area. A group of somewhat larger spine-bases occur near, and slightly oblique to, the hinge.

Brachial valve gently concave over the visceral region, and becoming geniculate anteriorly. Surface of the valve marked in a manner similar to that of pedicle valve. Internally the slender cardinal process is bifid, each division of which possesses a small cup-like cavity; anterior to the process a median septum extends to the edge of the visceral area, and cardinal ridges extend laterally from each side of the cardinal process; raised, lobate, muscular impressions lie just anterior to the lateral ridges; the brachial impressions are distinctly

visible and lie posterior to the middle of the valve; short oblique spines arranged along the costae occur on the anterior half of the valve.

Remarks.—This species occurs commonly in the limestone near Grand Ledge. In outward appearance the umbonal region of *P. smithi* resembles *Marginifera muricata* var. *missouriensis.* Mature specimens are readily distinguished by their greater size, the proportions of length to breadth, and the presence of fewer spines on the anterior and anterolateral slopes of *P. smithi.*

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich. Also in argillaceous limestone fragments collected from mine dump near mouth of Six-mile Creek, Shiawassee Co., Mich.

Present location.—The holotype (18Sf15.1) and paratypes (18Sf15.2 to 18Sf15.6) are in the collections of Michigan State College, East Lansing, Mich. The specific name has been given in honor of Mr. R. A. Smith, state geologist of Michigan.

Genus MARGINIFERA Waagen

MARGINIFERA MURICATA var. MISSOURIENSIS Girty

Plate 11, figs. 6, 7

1915. *Marginifera muricata* var. *missouriensis* GIRTY, Missouri Bureau Geol. and Mines, vol. XIII, 2nd Ser., p. 350, pl. XXX, figs. 2-5*a*. (Cherokee shale, Missouri.)

1922. *Marginifera muricata* var. *missouriensis* MORNINGSTAR, Geol. Survey of Ohio, 4th ser., Bull. 25, p. 184, pl. 9, figs. 1-5. (Upper part of Pottsville formation, Ohio.)

Description.—Shell small, the dimensions of an average individual being: length 11.5 mm., width 13.0 mm., height 7 mm. The pedicle valve is usually very gibbous and imparts a globular appearance to the shell. The surface of the posterior portion of the umbo is marked only by spines and concentric ribs, but both costae and ribs are found on anterior half of the visceral region, while costae only are present in front of this area. There are usually about 8 costae in 5 mm. Scattered spines are present over the entire shell but are more numerous in the posterior region. A single row of spines is present near the hinge line. Brachial valve concave, somewhat flattened over visceral area, but usually with marked concavity near the posterior portion, so that impressions of this valve have a sinuate section. Internally the ridge bounding the visceral cavity is weakly developed except near the posterior edges.

Remarks.—The individuals of this variety which possess relatively low convexity resemble *Marginifera muricata,* but in general are smaller, have a finer ornamentation, and lack any suggestion of a sinus.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich. Also in fragments of argillaceous limestone and highly pyritized argillaceous limestone collected from mine dump near mouth of Six-mile Creek, Shiawassee Co., Mich.

MARGINIFERA aff. WABASHENSIS (Norwood and Pratten)

Remarks.—A single specimen of a small, gibbous pedicle valve, characterized by a prominent sinus and the lack of costae is probably related to, although not identical with *Marginifera wabashensis.* The dimensions, length 9 mm., width 10 mm., convexity 5 mm., are somewhat less than those usually given for *M. wabashensis.* Dr. Marvin Weller, **(9)** to whom the Michigan specimen was loaned, states that it is a primitive type of *M. wabashensis,* and resembles closely a form from the Lower Pennsylvanian of Indiana.

Horizon and locality.—Saginaw formation; highly pyritized argillaceous limestone fragment from New Haven township, Shiawassee Co., Mich., probably from mine in bed of Six-mile Creek.

Genus SPIRIFER Sowerby

SPIRIFER BOONENSIS Swallow?

1860. *Spirifer boonensis* SWALLOW, Trans. St. Louis Acad. Sci., vol. I, p. 646. (Lower Coal Measures, Missouri.)

1903. *Spirifer boonensis?* GIRTY, U. S. Geol. Survey Prof. Paper 16, p. 381, pl. 6, fig. 13. (Carboniferous of Colorado.)

1922. *Spirifer boonensis?* MORNINGSTAR, Geol. Survey of Ohio, 4th Ser. Bull. 25, p. 186, pl. 9, figs. 21-25. (Pottsville formation of Ohio.)

Remarks.—A single specimen from Michigan shows the characters of *Spirifer boonensis* as interpreted by Girty. The simple rounded plications on each side of the sinus, and the elevated and laterally flattened beak, strongly suggest this species. The specimen agrees well with a homeotype of *S. boonensis* borrowed from Walker Museum.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

SPIRIFER CAMERATUS Morton
Plate 11, fig. 17

1836. *Spirifer cameratus* MORTON, Am. Journ. Sci., 1st, ser., vol. 29, p. 150, pl. 2, fig. 3. (Coal Measures; Putnam Hill, Zanesville, Ohio.)

Description.—Shell large, subquadrate in outline, width exceeding length, the greatest width being at the hinge. The dimensions of a pedicle valve are: length 29+mm., width 45 mm., height of cardinal area measured at delthyrium 4 mm., width of delthyrium 6 mm. Mesial sinus well defined, rounded, and occupied by 6 to 10 plications; lateral slopes each bearing 17 plications, which show a tendency towards slight fasciculation; entire surface where well preserved crossed by numerous, closely spaced fine, concentric lines. Cardinal area slightly curved, transversely and vertically striate, and possessing a crenulate hinge margin. Brachial valve not observed.

Remarks.—This species is represented by a few specimens only in the Michigan faunas. Its relationship with *Spirifer goreii*, the holotype of which was borrowed from Walker Museum, is indicated in the general outline of the shell and in the crenulate hinge area. It differs in the tendency towards a grouping of plications. *Spirifer cameratus* is ordinarily thought to be characterized by strong fasciculation, but forms of this type, according to Dunbar, **(6)** will be grouped under another species, *Sp. triplicatus*.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.; also one specimen from an unknown locality.

Genus COMPOSITA Brown

COMPOSITA SUBTILITA (Hall)

1842. *Terebratula Roissyi* D'ORBIGNY (not L'EVEILLE), Voyage dans l'Amérique meridionale, PALEONTOLOGY, vol. III, pt. 4, p. 46. (Carboniferous; Yarbichambi, Bolivia.)

1852. *Terebratula subtilita* HALL, Stansb. Expl. and Survey Great Salt Lake of Utah, p. 409, pl. 4, figs. 1, 2. (Carboniferous; Missouri River, near Weston.)

1915. *Composita subtilita* GIRTY, U. S. Geol. Bull. 544, p. 96, pl. 12, fig. 4. (Wewoka formation, Oklahoma.)

Remarks.—Several fragments of elongate-ovate, smooth-shell brachiopods are referred to the genus *Composita*. These specimens possess a mesial line along the center of a shallow median sinus. A few specimens approach *C. gibbosa*, and one specimen approaches *C. ovata*, but from the poor material at hand, it seems safer to refer the

specimens for the present to the more inclusive species, *C. subtilita.*

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich. Also highly pyritous, argillaceous limestone fragments collected from mine dump near mouth of Six-mile Creek, Shiawassee Co., Mich.

Genus NAIADITES Dawson

NAIADITES ELONGATA Dawson

Plate 11, fig. 12

1860. *Naiadites elongata* DAWSON, Supp. Acad. Geol., p. 43. (Coal Measures; Nova Scotia.)

1922. *Naiadites elongata* MORNINGSTAR, Geol. Survey of Ohio, 4th Ser., Bull. 25, p. 220, pl. XII, figs. 7-9. (Lower Pottsville of Ohio.)

Remarks.—A single species of pelecypod makes up an entire faunule in a hard, shale layer occurring immediately below the limestone member at Grand Ledge. The specimens are crushed, but show the oblique form, and fine, concentric ornamentation of *Naiadites elongata,* to which species they are referred.

Horizon and locality.—Saginaw formation; shale below limestone member; quarry of Grand Ledge Face Brick Co., near Grand Ledge, Mich.

Genus ASTARTELLA Hall

ASTARTELLA COMPACTA Girty

1915. *Astartella compacta* GIRTY, Missouri Bureau Geol. and Mines, ser. 2, vol. XIII, p. 354, pl. 28, figs. 4, 4 *a*, 5, 5 *a*. (Cherokee formation, Missouri.)

1922. *Astartella compacta* MORNINGSTAR, Geol. Survey of Ohio, 4th Ser., Bull. 25, p. 241. (Pottsville of Ohio.)

Remarks.—A few specimens of a small, subquadrate pelecypod with the outer characteristics of an *Astartella* are found in the Saginaw formation. It is closely allied to *A. compacta* judging from the proportions of length to height, and the numerous closely arranged, concentric lamellae. It differs chiefly in point of size, the Michigan specimens being about two-thirds the size of those figured by Girty.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

Class GASTROPODA

Genus WORTHENIA DeKoninck

WORTHENIA TABULATA (Conrad)
Plate 11, fig. 19

1835. *Turbo tabulatus* CONRAD, Pennsylvania Geol. Soc. Trans., vol. I, pt. 2, p. 267, pl. 12, fig. 1.
1884. *Pleurotomaria tabulata* WHITE, Indiana Dept. Geol. and Nat. Hist. 13th Ann. rept., pt. 2, pl. 32, figs. 4, 5. (Upper Coal Measures of Indiana.)
1915. *Worthenia tabulata* GIRTY, U. S. Geol. Survey, Bull. 544, p. 152, pl. 22, figs. 1-4*a*. (Wewoka formation, Oklahoma)

Remarks.—The Michigan specimens possess the characters enumerated by Girty in his description of the Wewoka forms. *Worthenia tabulata* is frequently found in a crushed condition, and fragments of the highly ornamented shell are quite common.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

Genus IGOCERAS Hall

IGOCERAS, sp.

Description.—Shell large, with small cone surmounting a wide horizontal flabellate expansion at least 40 mm. in diameter; total height about 10 mm., height of conical apex 7 mm. Surface smooth, with a few gentle undulations. The position of the apex of the cone with regard to the border of the shell is indeterminable.

Horizon and locality.—Saginaw formation; limestone member; quarry of the Grand Ledge Face Brick Co., near Grand Ledge, Mich.

Class CEPHALOPODA

Genus PSEUDORTHOCERAS Girty

PSEUDORTHOCERAS KNOXENSE (McChesney)
Plate 11, fig. 13

1860. *Orthoceras knoxensis* MCCHESNEY, Desc. New Spec. Foss., p. 69. (Date of imprint, 1859.) (Coal Measures, Danville, Illinois.)
1884. *Orthoceras rushensis* WHITE, Indiana Dept. Geol. and Nat. Hist. 13th Ann. Rept., pt. 2, p. 164, pl. 36, fig. 5. (Coal Measures, Indiana.)
1915. *Pseudorthoceras knoxense* GIRTY, U. S. Geol. Survey Bull. 544, p. 227, pl. 27, figs. 1-6. (Wewoka formation, Oklahoma.)
1922. *Pseudorthoceras knoxense* MORNINGSTAR, Geol. Survey of Ohio, 4th Ser., Bull. 25, p. 268. (Pottsville of Ohio.)

Description.—Shell a smooth orthocone with small apical angle; septal angle about 85 degrees; siphuncle central, or nearly so. Internally the species shows the distinguishing characters of the genus, the siphuncle expanding between the septa, and the chambers being occupied by secondary deposits which accumulated about the walls.

Remarks.—This is the most common cephalopod of the Saginaw formation. Fragments showing half a dozen chambers are common, and specimens 3 and 4 inches in length are not uncommon.

Horizon and locality.—Saginaw formation; limestone member; Face Brick quarry of Grand Ledge Co. near Grand Ledge, Mich.; also reported from Verne mine, Saginaw County, and Michigan mine, Bay County.

REGISTER OF LOCALITIES

A.—Jackson County.
B.—Quarries and outcrops in the vicinity of Grand Ledge.
C.—Quarry of the New Corunna Brick Co., about 2 miles east of Corunna, Mich.
D.—Mine dumps in valley of Six-mile Creek, New Haven township, Shiawassee Co., and a few specimens labelled, New Haven township, probably from same locality.
E.—Verne Mine, Saginaw Co., Mich.
F.—Uncle Henry Mine No. 2, Saginaw Co., Mich.
G.—Michigan Coal and Mining Company Mine, Saginaw Co., Mich.
H.—Michigan Coal Mine, Bay Co., Mich.
I.—Monitor Coal Mine, Bay Co., Mich.

REGISTER OF HORIZONS AT GRAND LEDGE

a.—The Lingula shale occurring below the main coal seam at Grand Ledge, and close to the base of the section at Grand Ledge.
b.—Shales and sandstones above the coal, and below the limestone.
c.—Black, argillaceous limestone carrying marine faunule.

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SOME UPPER CARBONIFEROUS OSTRACODA FROM THE SHALE BASIN OF WESTERN TEXAS

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ABSTRACT

The rapidly changing character of the Upper Carboniferous sediments deposited in the Shale Basin of Western Texas makes lithologic correlation difficult. Faunal methods of correlation in such an area are invaluable. A study of a part of the micro-fauna from some of the wells drilled in the area is undertaken here with the hope that it may be of aid to subsurface workers. A number of new species and two new genera are described.

The ostracoda described in the following pages were secured from cable-tool well cuttings. The table on page 2 lists the location and elevation of the wells. No attempt has been made to place the described forms stratigraphically.

The writer wishes to acknowledge his debt to the following: Mr. A. L. Selig and Mr. A. L. Ackers of the Southern Crude Oil Purchasing Company for use of the ostracoda described and much additional helpful data; Mr. P. V. Roundy, Dr. R. C. Moore and Mr. J. Brookes Knight for their invaluable aid in editing the text; Miss Betty Kellett for help in classification of the Hollinellids; and Miss Helen Huntington for her able assistance in the preparation of the photo-micrographs.

The wells from which the ostracodes were secured are as follows:

IRION COUNTY

Kingwood Oil Co., Suggs No. 1, Blk. 1, Sec. 19, H. & T. C. Survey; 1,650 feet from S. & E. lines. Elevation 2,334 feet.

Sun Oil Co., Tankersley No. 1, Sec. 8, G. C. & S. F. Survey (Abstract 1,122); 2,128 feet from S., 173 from W. line. Elevation 2,253 feet.

Whittmer Property Trustees (Cash Dollar), A. Mayer No. 2, Sec. 1,127, G. C. & S. F. Survey; 1,000 feet from N., 2,640 from E. lines. Elevation 2,050.

MENARD COUNTY

C. Cromwell et al, Winslow No. 1, Sec. 32, T. & N. O. Survey; center of S. E. quarter-section.

PECOS COUNTY

Transcontinental Oil Co., Blackstone-Slaughter No. 1, Blk. 129, Sec. 29, T. & St. L. Survey; 250 feet from S., 1,250 from W. lines. Elevation 3,635 feet.

SCHLEICHER COUNTY

Ft. McKavett Oil Co., Tisdall No. 1, River Sec. 1,499, Wilhelm Helm Survey; center of section. Elevation 2,151 feet.

SUTTON COUNTY

Southern Crude Oil Purchasing Co., Allison No. 1, Blk K, Sec. 44, G. H. & S. A. Survey; 2,310 feet from N., 330 feet from E. lines. Elevation 2,373 feet.

Family APARCHITIDAE Ulrich and Bassler

Genus PARAPARCHITES Ulrich and Bassler

PARAPARCHITES HUMEROSUS var. TEXANA Delo, n. var.

Plate 12, fig. 1

Shell small for the species, quite convex; lateral outline sub-elliptical. Dorsal margin gently convex, in lateral view formed by the obese upper portions of the valves. Cardinal angulation very slight anteriorly, the posterior distinct and very widely obtuse. Ventral margin smoothly and broadly curved, without a break at the ex-

tremities; trending rapidly upward throughout the anterior three-fourths of its length. Posterior extremity much the higher, broadly produced in ventral portion; anterior extremity more narrowly but evenly rounded with equal dorsal and ventral curvature. Highest portion of the shell just in front of the post-dorsal angle; greatest convexity just in front of the center of the upper third of the shell.

Overlap of the right valve upon the left moderate, everywhere visible except along the dorsal margin. A slight flattening of the margin of the valves gives a suggestion of a rim around the free margins. This feature is more apparent on the right valve. Viewed dorsally, the hinge line is seen to be depressed between the swelled upper portions of the valves, extending about one-half the total length of the shell.

Length, 0.96 mm.; Height, 0.70 mm.; Thickness, 0.46 mm.

Locality.—C. Cromwell, Winslow No. 1. Depth, 600-20 feet.

This variety differs from typical *P. humerosus* Ulrich and Bassler in its much smaller size and the greater ratio of posterior height. All the specimens studied have shown the general characters of the figured individual. The character of the material studied suggests that they are conspecific with *P. humerosus*, but the differences outlined above are so constant as to place them in a new variety.

PARAPARCHITES BIMAMMATUS Delo, n. sp.
Plate 12, fig. 2

The shell is small for the genus and quite convex. The dorsal margin of the right valve straight, that of the left valve slightly convex; the hinge line occupying almost the entire dorsal margin. Cardinal angles seen from the right side indistinct: from the left obtuse, moderately distinct, subequal.

Anterior extremity the more narrowly curved, about two-thirds the height of the posterior, which is prominently produced in the lower median portion. The ventral margin is a broad curve, the anterior portion trending upward, and about twice as long as the posterior part. Highest portion of the shell about one-third the length of the hinge in front of the posterior cardinal angle; greatest convexity about one-third the height of the shell below the dorsal margin and a little in front of the center.

Overlap of the right valve moderate, greatest in median ventral portion; the left valve extending well above the right along the hinge.

The left valve is the more convex, with a broad inflation about one-third the length of the hinge in front of the posterior angle, the up-

per portion of the swelling slightly inflecting the dorsal profile. Greatest slope of the swelling is ventral and posterior, but is nowhere marked. The right valve is less convex slightly flattened in the lower central and anterior portion, with a conspicuous elongate swelling occupying the median third of the ventral margin and very slightly inflecting the ventral profile.

Length, 0.80 mm.; Height, 0.56 mm.; Thickness 0.38 mm.

Locality.—Transcontinental, Blackstone-Slaughter No. 1. Depth, 1,365-75 feet.

Several specimens of various sizes have been examined from this locality, all showing the prominent dorsal inflation of the left valve and the conspicuous elongate ventral swelling on the right valve. The dimensions given are those of an average specimen.

PARAPARCHITES ORNATUS Delo, n. sp.
Plate 12, fig. 3

Shell of medium size; rather suboval in lateral outline. Dorsal margin arched, the anterior two-thirds occupied by the rather straight hinge line, and sloping toward the anterior extremity; the posterior third curved, meeting the posterior end of the hinge with wide indistinct angulation, and rounding without a break into the posterior extremity. Anterior extremity rather flatly curved, trending backward ventrally, with a broader ventral than dorsal curve. Posterior extremity higher, evenly curved. The ventral margin occupies the median half of the shell, is slightly and broadly concave, and meets the extremities regularly.

Greatest height at the posterior end of the hinge; greatest convexity median.

Overlap of the right valve upon the left is indistinct, present throughout except along the hinge. The edges of the valves are flattened producing a rimmed effect which is more prominent on the right valve, and everywhere more distinct than the line of overlap. The surface of the valve is decorated with a regularly arranged more or less concentric pattern of shallow pits.

Length, 1.16 mm.; Height, 0.72 mm.; Thickness, 0.48 mm.

Locality.—Cash Dollar. Depth, 1,850-65 feet.

Family BEYRICHIIDAE Jones, restricted Ulrich and Bassler

Genus HOLLINELLA Coryell, emend. Kellett

HOLLINELLA HERRICKIANA (Girty)
Plate 12, fig. 4

Hollina herrickiana GIRTY, 1909, U. S. Geol. Survey Bull. 389, p. 115, pl. 8, figs. 10-11. (Yeso formation, Manzano group; San Andreas mountains, New Mexico.)

Shell small; lateral outline more or less sub-elliptical. Dorsal margin straight, extending about five-sixths the length of the shell, and occupied by the hinge. Posterior extremity the higher, broadly and regularly curved; anterior extremity evenly curved but trending backward throughout the lower two-thirds of its length. Ventral margin broadly convex. Highest portion of the shell median.

The anterior node is of moderate size, abrupt, and quite high, arising a little below the dorsal margin and about one-fourth the length of the hinge behind the anterior cardinal angle. It is continued downward as a prominent curved ridge which curves downward and backward about three-fourths the height of the shell, hence curving upward and meeting the dorsal margin just in front of the posterior cardinal angle. The anterior half of the ridge is much the higher. The posterior node is small, located just within the posterior curve of the ridge and about one-fifth the height of the shell below the dorsal margin. No marginal frill is present. Surface of the shell finely granulose.

Length, 0.60 mm.; Height, 0.32 mm.

Locality.—Kingwood, Suggs No. 1. Depth, 1,382-86 feet.

HOLLINELLA OCCIDENTALIS (Girty)
Plate 12, fig. 5

Hollina emaciata var. *occidentalis* GIRTY, 1910, U. S. Geol. Survey, Bull. 436, p. 55-56, pl. 7, figs. 8-10. (Park City formation; Thomas Fork Wyoming.)

Shell of medium size; lateral profile rather sub-rectangular. Dorsal margin straight, occupied by the hinge and extending about four-fifths the total length of the shell. Cardinal angles obtuse, distinct; the anterior the sharper. Anterior extremity regularly curved, trending backward, and joining the ventral margin evenly. Posterior extremity broadly rounded, produced slightly below. Ventral margin broadly convex, trending upward throughout the anterior two-thirds of its length, the posterior curve much more abrupt.

Greatest height about on a line with the posterior node. The anterior node, located about one-fourth the length of the hinge from the anterior cardinal angle, is large, its upper rounded surface on a line with the dorsal margin, and bearing a short, sharp spine which inflects the dorsal line of the shell. The posterior node is much smaller, located well below the dorsal margin and about one-fourth the length in front of the posterior cardinal angle. A conspicuous ridge arises below and slightly anterior to the anterior node, parallels the ventral and posterior margins of the shell, and disappears at the posterior cardinal angle. The ridge is bounded above and below by a narrow depression, is highest in median portion, and has an acute sub-angular post-ventral curve. The sulcus between the nodes is narrow and deep, and another narrower and shallower sulcus separates the posterior node from the ridge. A very narrow frill bounds the ventral margin, dying out on the lower portions of the anterior and posterior margins. Surface of the shell is smooth.

Length, 0.90 mm.; Height, 0.52 mm.

Locality.—Sun, Tankersley No. 1. Depth, 960-70 feet.

The figured specimen appears identical with Girty's figures 8 and 9, but is not identical with figure 10.

HOLLINELLA AUSTRALIS Delo, n. sp.
Plate 12, figs. 6, 7

Hollina emaciata var. *occidentalis* GIRTY, 1910, U. S. Geol. Survey, Bull. 436, p. 55-56, pl. 7, figs. 8-10.

This species is very similar to *H. occidentalis* in the arrangement and proportions of the nodes and sulcus, but differs in shape and the character of the large ridge. The straight hinge is shorter in proportion to the total length of the shell, the extremities well rounded and a little produced. Cardinal angles are not distinct as in *H. occidentalis*. The large ridge is broadest and highest in median part, almost disappearing on the anterior third, of moderate size on the posterior portion, and curving broadly in the post-ventral. An incipient frill is present on the ventral and posterior portion of the shell.

Length, 1.00 mm.; Height, .60 mm.

Locality.—Kingwood, Suggs No. 1. Depth, 1,525 feet.

The figured specimen appears identical with Girty's figure 10.

Family KIRKBYIDAE Ulrich and Bassler

Subgenus AMPHISSITES Girty emend. Roth

AMPHISSITES? SIMPLICISSIMUS? Knight

Plate 12, fig. 8

Amphissites simplicissimus KNIGHT, 1928, Journ. Pal., vol. 2, no. 4, p. 266-267, pl. 32, figs. 11 *a-d;* pl. 34, fig. 6. (Upper Fort Scott; St. Louis, Mo.)

Amphissites? simplicissimus HARLTON, 1929, Univ. of Texas, Bull. No. 2901, p. 151, pl. 1, figs. 13 *a-c.* (Canyon; Menard County, Texas.)

Shell of medium size for the genus; lateral outline almost subquadrate. Dorsal border straight, occupying about three-fourths the length of the shell. Dorsal angles obtuse, distinct, subequal. Straight portion of the ventral margin median, equalling about one-half the length of the shell; curving upward broadly and equally at the ends. Extremities equally curved, subequal in height.

Overlap of the larger left valve upon the right moderate; convexity subequal.

Reticulation uniform, of medium size; the Kirkbyan pit centrally located, consisting of an almost indistinguishable slightly depressed

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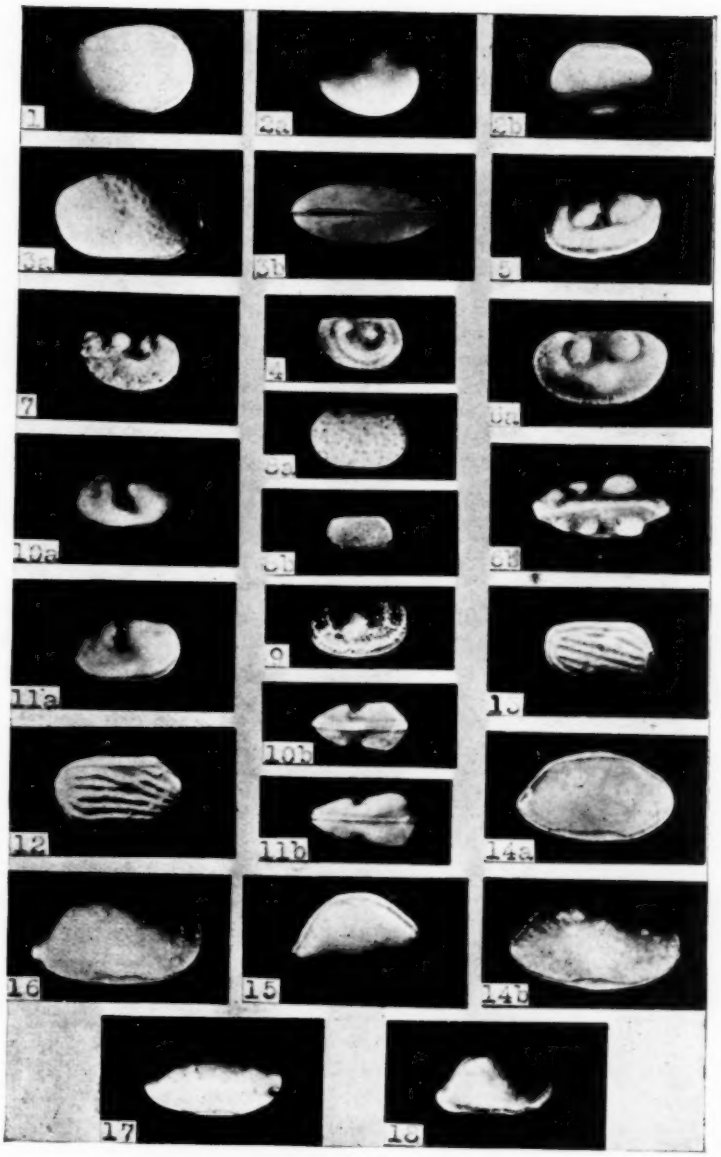
EXPLANATION OF PLATE 12

All figures ×20

FIG. 1.—*Paraparchites humerosus* var. *texana* Delo, n. var. Left valve.
2.—*Paraparchites bimammatus* Delo, n. sp. *a*, Left valve; *b*, right valve.
3.—*Paraparchites ornatus* Delo, n. sp. *a*, Left valve; *b*, dorsal.
4.—*Hollinella herrickiana* (Girty). Left valve.
5.—*Hollinella occidentalis* (Girty). Right valve.
6.—*Hollinella australis* Delo, n. sp. *a*, Right valve; *b*, dorsal. The apparent faulty orientation is caused by one valve being displaced from natural position.
7.—*Hollinella australis* Delo, n. sp. Left valve of small male.
8.—*Amphissites simplicissimus?* Knight. *a*, Right valve of described form; *b*, smaller individual.
9.—*Amphissites centronotus* (Ulrich and Bassler). Right valve.
10.—*Jonesina prolata* Delo, n. sp. *a*, Right valve;*b*, dorsal.
11.—*Jonesina subquadrata* Delo, n. sp. *a*, Right valve; *b*, dorsal.
12.—*Glyptopleura spinosa* Harlton. Left valve.
13.—*Glyptopleura emarginata* Delo, n. sp. Left valve.
14.—*Bairdia hispida* Harlton. Right valves.
15.—*Bairdia crassa* Harlton. Right valve.
16.—*Bairdia menardensis* Harlton. Right valve.
17.—*Bairdia seligi* Delo, n. sp. Right valve.
18.—*Bairdia irionensis* Delo, n. sp. Right valve.


1
2a
2b
3a
3b
5
7
8a
8b
10a
11a
9
10b
11b
12
14a
16
15
14b
17
18

smooth area roughly circular in shape, and about the size of four reticulations. Surface otherwise smooth, without the characteristic noding usually found in the genus. A narrow non-reticulate border extends around the edge of each valve.

Length, 0.76 mm.; Height, 0.48 mm.; Thickness, 0.36 mm.

Locality.—C. Cromwell, Winslow No. 1. Depth 760-90 feet.

The individuals figured do not correspond exactly with Knight's types, but agree so well in general character that examination of a large suite of specimens would be necessary to determine the true distinctions between them.

AMPHISSITES CENTRONOTUS (Ulrich and Bassler)
Plate 12, fig. 9

Kirkbya centronota ULRICH and BASSLER, 1906, U. S. Nat. Mus. Bull., vol. 30, no. 1446, p. 159, pl. 11, figs. 16-17. (Cottonwood shales; Cottonwood Falls, Kans.)

Amphissites centronota HARLTON, 1927, Journ. Pal., vol. 1, no. 3, p. 207, pl. 32, figs. 10 *a*, *b*. (Hoxbar formation; Carter County, Okla.)

Amphissites centronotus KNIGHT, 1928, Journ. Pal., vol. 2, no. 3, p. 259, pl. 32, figs. 6 *a-e*. (Upper Fort Scott limestone; St. Louis, Mo.)

The large central node, straight dorsal margin, and concentric arrangement of the ridges of the figured specimens are all typical of the species.

Length, 0.76 mm.; Height, 0.44 mm.; Thickness, 0.40 mm.

Locality.—Ft. McKavett, Tisdall No. 1. Depth, 1,730-50 feet.

Genus JONESINA Ulrich and Bassler

JONESINA PROLATA Delo, n. sp.
Plate 12, fig. 10

Shell of medium size for the genus; lateral profile sub-elliptical. Dorsal margin rather irregularly convex, the anterior two-thirds straight, gently sloping; the posterior third gently curved, steeper, giving the impression of a hump along the posterior third of the dorsal margin behind the sulcus. Anterior cardinal angle the more abrupt; anterior extremity a flat curve. Posterior extremity more prominently rounded, much higher than the anterior; dorsal and ventral curvature equal. Ventral margin convex, trending upward in a broad curve throughout the anterior two-thirds of its length. Highest portion of the shell about one-third from the posterior end; greatest convexity median, about one-third the height above the ventral margin.

Overlap of the left valve prominent except dorsally; the valves of almost equal size.

A broad deep median sulcus extends vertically for about one-half the height of the shell, and is produced forward and downward toward the ventro-anterior angle. The lower end of the sulcus is about one-fourth the height of the shell above the ventral margin. The anterior node is prominent, connected to the posterior node which bounds the posterior side of the sulcus, by a prominent elongate swelling along the ventral third of the valve. An inconspicuous swelling is present midway between the median sulcus and the posterior extremity. The valves are flattened below, dropping abruptly to the line of overlap. The flattening is more prominent anteriorly, where the valves are most convex, disappearing along the regularly tapering posterior portion. This condition is reflected on the left valve by an elongate anterior depression just above the overlapping edge, and disappearing along the posterior third.

Length, 0.76 mm.; Height, 0.48 mm.; Thickness, 0.48 mm.

Locality.—Sun, Tankersley No. 1. Depth, 892-906 feet.

This species superficially resembles *J. gregaria* Ulrich and Bassler, but differs from that species in the convex dorsal margin and character of the median sulcus.

JONESINA SUBQUADRATA Delo, n. sp.
Plate 12, fig. 11

Shell of medium size; lateral profile rather rectangular. Dorsal margin straight except for a slight broad convexity in front of the sulcus; the hinge occupying the entire margin which is about three-fourths the length of the shell. Cardinal angles distinct, obtuse, subequal. Extremities regularly curved, the posterior the higher, slightly produced below the middle; the anterior trending a little backward in ventral portion. Median portion of the ventral margin straight, the posterior upward curve a little the shorter.

Overlap of the left valve distinct, rather prominent in median ventral portion; valves subequal.

A deep sulcus is present a little behind the middle of the valve, extending downward about one-third the height of the shell. Another shallow inconspicuous sulcus is present just in front of the posterior cardinal angle. The anterior nodes form the thickest and most prominent portion of the shell, the area of greatest convexity broad and trending obliquely upward and backward toward the junction of the median sulcus and the dorsal margin, and there form-

ing the slight convexity of the margin noted above. Ventral portion of the valves abrupt. Viewed dorsally the point of greatest thickness is through the anterior nodes and very near the anterior end, the general outline of the shell tapering to the much thinner posterior end, and interrupted midway by the median sulcus. In ventral view a depression is located just posterior to the anterior nodes, about one-third the length of the shell behind the anterior extremity.

Length, 0.82 mm.; Height, 0.50 mm.; Thickness, 0.40 mm.

Locality.—C. Cromwell, Winslow No. 1. Depth, 600-20 feet.

This species differs from *Jonesina prolata* in the more rectangular lateral profile and the character of the median sulcus. It differs from *J. gregaria* Ulrich and Bassler in the rectangular lateral profile, the lesser anterior inflation, and greater regularity of the surface configuration.

Genus GLYPTOPLEURA Girty

GLYPTOPLEURA SPINOSA Harlton

Plate 12, fig. 12

Glyptopleura spinosa HARLTON, 1929, Univ. of Texas, Bull. No. 2901, p. 148, pl. 1, fig. 18. (Canyon; Menard County, Texas.)

Shell small, lateral profile subquadrate. Dorsal margin straight, the anterior cardinal angle distinct; the posterior, because of the swelled rim of the valve, almost a right angle, hence dropping steeply and straightly to the regularly curved and slightly elongated posterior extremity. Anterior extremity regularly rounded, trending backward. Ventral margin almost straight in median portion, curving regularly to meet the extremities.

Overlap of the left valve upon the right distinct, particularly when seen ventrally; margins of the valves thick and broad.

The primary ridge rises a little behind the anterior margin just below the anterior cardinal angle, and bifurcates midway. A short ill-defined ridge is present above, just below the posterior cardinal angle; another short ridge present below the anterior half, terminating at the central pit. Below are four parallel ridges, the upper three of equal length, the lowest occupying the median portion of the valve. The central pit is located just below the point of bifurcation of the primary ridge, the dorsal pit above. All the large ridges are incipiently spinose at the anterior end.

Length, 0.96 mm.; Height, 0.56 mm.; Thickness, 0.48 mm.

Location.—Fort McKavett, Tisdall No. 1. Depth, 2,270-90 feet.

GLYPTOPLEURA EMARGINATA Delo, n. sp.
Plate 12, fig. 13

Shell small, more or less subquadrate; only moderately inflated. Dorsal margin straight, cardinal angles distinct, the posterior the more abrupt; extremities regularly curved, the posterior the higher. Ventral margin smoothly and broadly curved. Valves subequal, overlap of the left indistinct.

Surface marked by a series of three large and two small ridges; the large ridges occupying the central portion of the valve, trending obliquely along a line from the dorso-anterior to the post-ventral angles. A small ridge, paralleling the margin, is located just below the posterior cardinal angle and extends about two-thirds the length of the shell, being interrupted midway by the dorsal pit. A small ventral ridge occupies the median portion of the shell adjacent to and parallel with the ventral margin. A smooth elevated rim extends around the entire margin, and is joined with only slight interruption by the three large central ridges and the posterior end of the small dorsal ridge. The central pit is located just below and about midway of the upper large ridge.

Length, 0.80 mm.; Height, 0.44 mm.; Thickness, 0.32 mm.

Locality.—Transcontinental, Blackstone-Slaughter No. 1. Depth, 1,365-75 feet.

This species differs from the described forms of *Glyptopleura* in the smaller number and arrangement of the ridges, the simple character of the primary ridge, and the presence of the marginal rim.

Family BAIRDIIDAE Ulrich and Bassler

Genus BAIRDIA McCoy

BAIRDIA HISPIDA Harlton
Plate 12, fig. 14

Bairdia hispida HARLTON, 1928, Journ. Pal., vol. 2, no. 2, p. 140, pl. 21, fig. 14. (Cisco formation; Eastland County, Texas.)

Bairdia hispida HARLTON, 1929, Univ. of Texas, Bull. No. 2901, p. 155, pl. 3, figs. 2 *a*, *b*. (Canyon; Menard County, Texas.)

Lateral outline of the shell subrhomboidal, with bluntly acuminate extremities. Dorsal margin moderately arched, the posterior third steeper than the anterior, subequal in length. Ventral margin broadly convex, the posterior upward curve shorter and more abrupt. Greatest height and thickness median. Dorsal overlap of the left valve thick, the line of junction of the valves with distinct angularity

at the inner ends of the posterior and anterior slopes, the former the steeper. Ventral overlap only prominent in median portion.

Length, 1.2 mm.; Height, 0.72 mm.; Thickness, 0.56 mm.

Locality.—C. Cromwell, Winslow No. 1. Depth, 600-20 feet.

Length, 1.36 mm.; Height, 0.80.

Locality.—C. Cromwell, Winslow No. 1. Depth, 1,000 feet.

BAIRDIA CRASSA Harlton
Plate 12, fig. 15

Bairdia crassa HARLTON, 1929, Univ. of Texas, Bull. No. 2901, p. 158, pl. 4, figs. 3 *a-c.* (Canyon; Menard County, Texas.)

Shell small, inflated; lateral profile subrhomboidal. Dorsal margin highly arched, the posterior slope much the longer and steeper. Posterior extremity moderately acuminate, sharply pointed. Anterior extremity regularly rounded; point of greatest elongation about midway of the height of the shell. Ventral margin almost straight, the anterior upward curve the more abrupt.

Overlap of the larger left valve prominent throughout, conspicuous in dorso-median portion. Greatest height median; greatest convexity in the post-dorsal portion, the swelled shoulder of the right valve sometimes extending above the line of overlap.

Length, 1.0 mm.; Height, 0.68 mm., Thickness, 0.56 mm.

Locality.—Ft. McKavett, Tisdall No. 1. Depth, 1,510-15 feet.

BAIRDIA MENARDENSIS Harlton
Plate 12, fig. 16

Bairdia menardensis HARLTON, 1929, Univ. of Texas, Bull., No. 2901, p. 158, pl. 4, figs. 1 *a-d.* (Canyon; Menard County, Texas.)

Shell large; lateral profile subrhomboidal. Dorsal margin highly arched, the median third only gently curved and sloping decidedly toward the posterior extremity. Dorsal anterior margin with moderate slope, broadly concave near the anterior end. Dorsal posterior slope steep and straight, with a slight upward and outward tilt at the lower end. Ventral margin almost straight in median portion, curving upward abruptly about one-fourth the length from the anterior end. The posterior upward curve is longer and more gentle. Posterior extremity moderately acuminate, pointed; greatest elongation about one-third the height of the shell from the ventral margin. Anterior extremity about two-thirds the height of the shell, regularly curved, produced above and trending backward throughout the lower four-fifths of its height.

Greatest height just anterior to the middle of the shell; greatest convexity median. Overlap of the larger left valve prominent along the dorsal margin, greatest in median portion. Ventral overlap only distinct along the median third.

Length, 1.32 mm.; Height, 0.76 mm.; Thickness, 0.56 mm.

Locality.—C. Cromwell, Winslow No. 1. Depth, 775 feet.

This species has a resemblance to *B. hispida* Harlton, but differs in the more pointed posterior, lesser angularity along the line of dorsal overlap, and lack of prominent overlap along the ends of the ventral margin.

BAIRDIA SELIGI Delo, n. sp.
Plate 12, fig. 17

Shell elongate, length about one and two-thirds times the height. Dorsal margin a regular curve, broadly concave at either end. Extremities subequally acuminate, the anterior the higher and blunter. Ventral margin broadly and evenly convex, with subequal upward curvature at the ends, the anterior slightly the longer.

Greatest height and thickness median. Overlap of the left valve prominent and subequal along the entire dorsal margin; only distinct ventrally along the median fourth of the margin.

Length, 1.08 mm.; Height, 0.60 mm.; Thickness, 0.44 mm.

Locality.—So. Crude Oil Pur. Co., Allison No. 1. Depth, 950-61 feet.

The general lateral outline of this species bears a resemblance to that of *Bairdia hispida* Harlton. It differs in the even curvature of the dorsal line of overlap, regularly convex margins and smaller size. The writer is aware of no other species with which it could be easily confused.

This species is named for Mr. A. L. Selig, Chief Geologist of the Southern Crude Oil Purchasing Co., Fort Worth, Texas.

BAIRDIA IRIONENSIS Delo, n. sp.
Plate 12, fig. 18

Shell small; lateral profile subrhomboidal. Dorsal margin highly arched, the median portion a flat curve. Dorsal slopes subequal in length with moderate concavity near the lower ends; the posterior slope the steeper and straighter. Posterior extremity about one-half the height of the anterior, moderately acuminate, bluntly pointed. Anterior extremity regularly curved, more abruptly so above. Ven-

tral margin slightly concave throughout the median part, with subequal upward curvature at the ends.

Greatest height and convexity median. Overlap of the left valve distinct along the entire dorsal margin; only prominent ventrally along the median third.

Length, 0.92 mm.; Height, 0.48 mm.; Thickness, 0.38 mm.

Locality.—Kingwood, Suggs No. 1. Depth, 1,382-86 feet.

This species most resembles *B. pompiloides* Harlton, but differs in the less elongate and more abrupt extremities and much smaller size. It differs from *B. marginata* Harlton in the higher and more abrupt anterior extremity, gentler antero-dorsal slope and blunter posterior extremity.

BAIRDIA PECOSENSIS Delo, n. sp.
Plate 13, fig. 1

Shell large, elongate; the length about twice the height. Dorsal margin curved, dropping steeply to the pointed acuminate posterior extremity, with a broad distinct concavity near the lower end of the slope. The anterior dorsal slope is broadly concave, only gently sloping. Anterior extremity about three-fourths the height of the shell, most abrupt above, curving regularly and trending backward below to join the ventral margin. Ventral margin straight, curving upward regularly and subequally at the ends.

Greatest height a little anterior to the center of the shell; greatest convexity median. Viewed dorsally, the shell is seen to be very thick throughout the median half of its length, curving suddenly and rapidly toward the ends. The valves are quite unequal in size, the left much the larger. The ventral side of the shell is greatly flattened. Overlap is conspicuous along the dorsal margin, the edges of the valves thickened and rounded. The overlap along the ventral margin is inconspicuous laterally, the edges of the valves meeting almost evenly. The surface of the shell is finely and rather evenly pitted giving somewhat the appearance of very finely pebbled leather.

Length, 1.48 mm.; Height, 0.76 mm.; Thickness, 0.84 mm.

Locality.—Transcontinental Blackstone-Slaughter No. 1. Depth, 1,032-38 feet.

The very convex character of the valves, abrupt anterior extremity and straight ventral border differentiate this species from any other known to the writer.

BAIRDIA SHIDELERI Delo, n. sp.
Plate 13, fig. 2

Shell elongate, length about twice the height. Dorsal margin curved, the median third almost straight, sloping slightly toward the posterior extremity. Post-dorsal slope steep, almost straight; the anterior slope longer and more gentle. Ventral margin slightly concave about one-third the length from the anterior end, the post-ventral angle the more abrupt. The extremities are blunt, the anterior the longer and about twice as high as the posterior.

Greatest height and convexity of the shell median. Overlap of the left valve prominent throughout except for a slight break at either end; everywhere subequal. The line of overlap shows no perceptible angularity. An apparent upward sinuosity of the ventral overlap is present about one-third the length from the anterior end.

Length, 1.12 mm.; Height, 0.56 mm.; Thickness, 0.40 mm.

Locality.—Transcontinental, Blackstone-Slaughter No. 1. Depth, 1,365-75 feet.

The lateral outline of this species resembles that of *B. hextensis* Harlton in some respects, but the difference in the dorsal slopes and the uniform overlap easily differentiate the two species. It differs from *B. subelongata* Jones and Kirkby in the bluntly rounded posterior extremity and arcuate dorsal margin. *B. shideleri* is named for the writer's valued friend and former teacher, Dr. W. H. Shideler, Professor of Geology at Miami University.

Genus BAIRDIANELLA Harlton

BAIRDIANELLA ELEGANS Harlton
Plate 13, fig. 3

Bairdianella elegans HARLTON, 1929, Univ. of Tex., Bull. No. 2901, p. 160, pl. 4, fig. 5. (Canyon; Menard County, Texas.)

Shell small, lateral outline rather sub-oval; pointed posteriorly. Dorsal margin regularly curved, the highest point about one-third the length of the shell from the anterior end. Posterior extremity pointed; anterior extremity blunt. Ventral margin straight. Overlap of the left valve thin, only perceptible ventrally. Viewed dorsally the shell is quite thick, greatest convexity median, with rather blunt anterior and pointed acuminate posterior extremities.

Length, 0.76 mm.; Height, 0.38 mm.; Thickness, 0.40 mm.

Locality.—Transcontinental, Blackstone-Slaughter No. 1. Depth, 1,365-75 feet.

Genus HEALDIA Roundy

HEALDIA OBSOLENS Delo, n. sp.
Plate 13, fig. 4

Shell of medium size, moderately inflated; dorsal margin a conspicuous curve with the highest point a little behind the middle of the shell, from which the anterior and posterior slopes curve moderately. Ventral margin convex, curving moderately at the extremities, the ventral junction of the valves slightly concave. Viewed dorsally the shell presents a lanceolate profile, the thickest portion about one-fourth the length from the posterior end; a slight inflection of the posterior curve about one-third the distance from the thickest portion to the posterior end marking the position of the posterior spines. Overlap of the left valve prominent throughout, conspicuous in median dorsal and ventral portions; greatest ventrally. Right valve distinctly smaller than the left.

Both valves bear a low indistinct posterior ridge, located about one-half the distance from the posterior end to the highest portion of the shell. The ridge is about as long as one-half the height of this portion of the valve, trends backward ventrally, and is located in a flattened, posteriorly sloping area bounded above and below by slight swellings, the lower the more prominent. Upper end of the ridge about one-third the height from the dorsal margin, the lower swelling about one-fifth the height above, and a little in front of the post-ventral angle.

Length, 1.0 mm.; Height, 0.68 mm.; Thickness, 0.52 mm.

Locality.—So. Crude Oil Pur. Co., Allison No. 1. Depth, 985-92 feet.

The very prominent overlap and indistinct posterior spines differentiate this species from other described Healdias.

HEALDIA LENTIFORMIS Delo, n. sp.
Plate 13, fig. 5

Shell small, subrhomboidal; dorsal margin highly arched, almost subangular medially. Posterior slope straight, longer and steeper than the anterior, which is gently curved. Anterior extremity the higher, rather narrowly curved, joining the dorso-anterior slope and ventral margin without perceptible angulation. Posterior extremity low, only slightly curved, trending a little forward ventrally; the dorsal angle the more abrupt. Ventral margin straight for about one-half its length, the anterior curve longer and more gentle than the posterior.

Viewed dorsally the thickest portion of the shell is about one-third from the posterior end, curving gently to the narrowly acuminate anterior, and steeply and straightly to the more bluntly rounded posterior. The even curve of the valves is broken at the thickest part by the outline of the dorsal spines.

Overlap of the left valve upon the right easily seen except along the post-dorsal slope; valves subequal.

The spines appear as large produced swellings arising without perceptible angulation from the surface of the valve. The upper spine is located just below and midway of the post-dorsal slope. The ventral spine is well posterior to the dorsal, at the post-ventral angle, so close to the border of the valve as to slightly inflect the smooth curve of the margin when viewed laterally. Between the spines is a somewhat flattened, rather ill-defined area, elliptical in shape, and bordered on the anterior side by a broadly rounded inconspicuous crescentic ridge. A slight depression bounds the posterior side of the flattened area and the spines. In dorsal view the upper spines are directed outward and backward, the ventral spines very slightly inflecting the blunt curve of the posterior profile.

Length, 0.72 mm.; Height, 0.44 mm.; Thickness, 0.40 mm.

Locality.—So. Crude Oil Pur. Co., Allison No. 1. Depth, 992-1,001.

This species has a superficial resemblance to *H. glennensis* Harlton when seen in lateral view, but the posterior extremity is proportionally much lower, the spines larger and located closer to the margins of the shell.

HEALDIA SUBANGULARIS Delo, n. sp.
Plate 13, fig. 6

Shell very small, elongate, sub-rectangular in lateral view, dorsal margin a broad curve, the anterior and posterior slopes of about equal length, the latter the straighter. Anterior extremity the higher, regularly curved; posterior extremity almost straight, trending slightly forward, meeting the post-dorsal slope angularly, curving sharply below. Ventral margin almost straight, slightly and broadly sinuate near the center, curving upward rather abruptly at the extremities.

Overlap of the left valve distinct, nowhere marked; indistinct along the posterior extremity and post-dorsal slope. Valves of equal size.

The posterior spines are located very close to the end of the shell; produced backward. The ventral spines extend beyond the post-ventral angle, and obscure it in lateral view. Dorsal spines extend above

the downward curving post-dorsal slope at the post-dorsal angle, resulting in a sharply angular posterior profile both above and below. Between the spines is a flattened, depressed area which slopes posteriorly and is bounded by a narrow posterior rim. Viewed from above, the narrowly swelled upper portion of each valve, produced posteriorly as the dorsal spines, trends outward and backward from the anterior end of the hinge, enclosing a triangular depressed area about one-third the length of the shell. The posterior rim bounding the vertical depressed area between the spines is visible in this view, accentuating the almost square-cut appearance of the posterior profile of the shell.

Length, 0.66 mm.; Height, 0.36 mm.; Thickness, 0.28 mm.

Locality.—So. Crude Oil Pur. Co., Allison No. 1. Depth, 992-1,001 feet.

This species resembles *Healdia overbrookensis* Harlton in lateral profile, but differs in that the spines are closer to the posterior margin and in the presence of the posterior rim.

HEALDIA ACKERSI Delo, n. sp.
Plate 13, fig. 7

Shell small, more or less subrhomboidal; highest portion of the dorsal margin located a little anterior to the middle. Anterior slope straight, steep; posterior slope the longer, gently curved. Posterior

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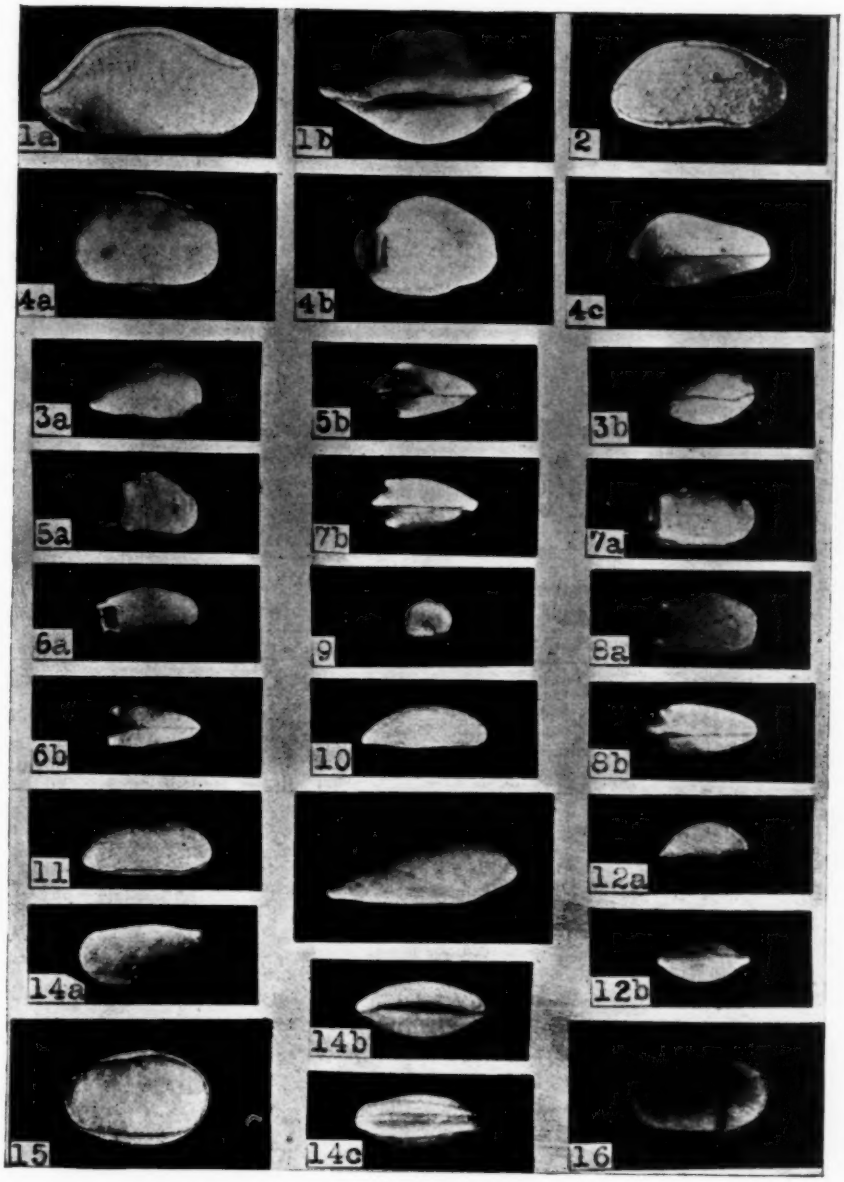
EXPLANATION OF PLATE 13

All figures ×20

FIG. 1.—*Bairdia pecosensis* Delo, n. sp. *a*, Right valve; *b*, dorsal.
2.—*Bairdia shideleri* Delo, n. sp. Right valve.
3.—*Bairdianella elegans* Harlton. *a*, Right valve; *b*, dorsal.
4.—*Healdia obsolens* Delo, n. sp. *a*, Right valve; *b*, left valve; *c*, dorsal.
5.—*Healdia lentiformis* Delo, n. sp. *a*, Right valve; *b*, dorsal.
6.—*Healdia subangularis* Delo, n. sp. *a*, Right valve; *b*, dorsal.
7.—*Healdia ackersi* Delo, n. sp. *a*, Right valve; *b*, dorsal.
8.—*Healdia concinna* Delo, n. sp. *a*, Right valve; *b*, dorsal.
9.—*Seminolites ovatus* Delo, n. sp. Right valve.
10.—*Macrocypris menardensis* Harlton. Right valve.
11.—*Argilloecia regularis* Delo, n. sp. Right valve.
12.—*Acratia typica* Delo, n. gen. et n. sp. *a*, Right valve; *b*, ventral.
13.—*Acratia magna* Delo, n. sp. Right valve
14.—*Kellettella naviculata* Delo, n. gen. et n. sp. *a*, Left valve; *b*, dorsal; *c*, ventral.
15.—*Cytherella ovoidiformis* Harlton. Left valve.
16.—*Cytherella constricta* Delo, n. sp. Left valve.


1a
1b
2
4a
4b
4c
3a
5b
3b
5a
7b
7a
6a
9
8a
6b
10
8b
11
12a
14a
12b
14b
15
14c
16

extremity the higher, broadly curved, meeting the post-dorsal slope evenly, sub-angular below. Anterior extremity more narrowly curved, the ventral angle the sharper. Ventral margin almost straight, with a slight broad central concavity.

Overlap of the left valve prominent throughout; valves subequal. Greatest thickness about one-third the length of the shell from the posterior end.

Posterior spines prominent, sharp; placed almost perpendicularly one above the other; connected by a sharp narrow ridge bordered anteriorly by a narrow flattened area. Behind the ridge the surface of the valve drops steeply to the rather prominent rim formed by the overlapping edge of the left valve. Only the upper spines are visible in dorsal view.

Length, 0.70 mm.; Height, 0.44 mm.; Thickness, 0.36 mm.

Locality.—So. Crude Oil Pur. Co., Allison No. 1. Depth, 985-92 feet.

This species has a lateral profile much like that of *Healdia ciscoensis* Harlton. The spines of *H. ackersi* are larger and closer to the posterior end and the anterior extremity proportionally lower.

H. ackersi is named for Mr. A. L. Ackers, District Geologist of the Southern Crude Oil Purchasing Co., Midland, Texas.

HEALDIA CONCINNA Delo, n. sp.
Plate 13, fig. 8

Shell small, with a subrectangular lateral profile. The dorsal margin is gently curved, anterior and posterior slopes straight, the former slightly the longer. Dorsal angles abrupt, the anterior slightly the sharper. Posterior extremity the higher, rather straight; dorsal and ventral angles subequal, abrupt. Anterior extremity trending backward ventrally, only flatly curved; dorsal and ventral angles rather sharp, subequal. Ventral margin rather straight, with very slight broad central concavity. Viewed dorsally the shell is lanceolate, the hingement area moderately conspicuous. Highest part of the shell median; thickest portion about one-third the length from the posterior end.

Overlap of the left valve distinct, subequal, except on the post-dorsal slope and the posterior extremity, where it is indistinct. Valves subequal in size.

Posterior spines small, sharp; the dorsal spines quite close to the margin, about two-thirds the distance from the highest portion of the shell to the posterior extremity; ventral spines on a line from

the dorsal spines to the ventro-posterior angle and very near the margin of the shell. Between the spines is a distinct semi-ellipsoidal area, depressed and flattened, and bounded by a slight narrow ridge from the apices of which arise the spines.

Length, 0.76 mm.; Height, 0.46 mm.; Thickness, 0.36 mm.

Locality.—So. Crude Oil Pur. Co., Allison No. 1. Depth 985-92 feet.

Healdia concinna superficially resembles *H. fayettevillensis* Harlton in lateral view, but the anterior extremity is much blunter, the spines closer to the posterior margin, and the shell much thinner. The lateral profile of *H. concinna* also resembles that of *H. nucleolata* Knight but the spines are larger, and the shell is larger and much more lanceolate in dorsal view.

Genus SEMINOLITES Coryell

SEMINOLITES OVATUS Delo, n. sp.
Plate 13, fig. 9

Shell very small, thick; lateral outline subrhomboidal. Dorsal margin highly arched; anterior and posterior slopes of about equal length and curvature, the latter slightly the straighter and steeper. Extremities of about equal height, the posterior the more broadly curved and with a slight forward trend ventrally. Ventral margin rather straight, the posterior angle the more abrupt.

Overlap of the larger left valve upon the right everywhere conspicuous; edges of the shell thick. Greatest convexity about one-fourth the length of the shell from the posterior end. A narrow curved ridge is present on both valves about one-fourth the length from the posterior extremity, occupying about two-thirds the height of that portion of the shell. It is more prominent on the right valve. The surface is otherwise smooth.

Length, 0.38 mm.; Height, 0.28 mm.; Thickness, 0.20 mm.

Locality.—Transcontinental, Blackstone Slaughter No. 1. Depth, 1,365-75 feet.

This species differs from other members of the genus known to the writer in the small size, prominent overlap and tumid character of the shell.

Genus MACROCYPRIS Brady

MACROCYPRIS MENARDENSIS Harlton

Plate 13, fig. 10

Macrocypris menardensis HARLTON, 1929, Univ. of Texas, Bull. No. 2901, p. 161, pl. 4, figs. 7 *a*, *b*. (Canyon; Menard County, Texas.)

Shell elongate, almost attenuate, small. Dorsal margin curved, ventral margin straight. Anterior extremity rather abrupt, the ventral angle sharp; posterior extremity sharply pointed, greatly produced. Greatest height and thickness median.

Overlap of the right valve present on all sides, almost imperceptible, greatest in median ventral portion.

Length, 0.86 mm.; Height, 0.32 mm.; Thickness, 0.28 mm.

Locality.—Transcontinental, Blackstone-Slaughter No. 1. Depth, 1,365-75 feet.

Genus ARGILLOECIA Jones and Kirkby?

ARGILLOECIA REGULARIS Delo, n. sp.

Plate 13, fig. 11

Shell small, lateral outline subrhomboidal; the length about twice the height. Median third of the dorsal margin a flat curve, the posterior slope straight and steep; the anterior slope more gentle and slightly curved. Extremities blunt, the anterior slightly the higher and more elongate. Ventral margin straight with even and subequal curvature at the ends. The larger left valve overlaps the right throughout, the overlap most prominent in median portion of the dorsal and ventral margins, but nowhere conspicuous. Greatest height and convexity median; surface smooth.

Length, 0.84 mm.; Height, 0.44 mm.

Locality.—Kingwood, Suggs No. 1. Depth, 1,527-45 feet.

As far as the writer is aware, this marks the first appearance of *Argilloecia* in the Carboniferous of North America.

Genus ACRATIA Delo, new genus

Acratia is characterized by the elongate, pointed character of the carcapace, both in lateral, dorsal and ventral views; the overlap of the left valve only present along the ventral and dorso-anterior margins; the straight ventral border with an abrupt upward anterior bend.

The genotype is *Acratia typica* Delo, n. sp. This genus resembles *Macrocypris* in some respects, but differs in the more pointed an-

terior extremity, the abruptly upward bent ventral margin, and the reversed overlap. It differs from *Bairdianella* in greater elongation, the more pointed anterior extremity, character of the ventral margin and the character of the overlap, as figures[1] of *Bairdianella* show the overlap of the left valve restricted to the ventral margin.

Examination of figures of *Bythocypris? rostrata* Knight[2] indicates that this form may very possibly be congeneric with *Acratia*, but no positive statement can be made without examination of the type material.

ACRATIA TYPICA Delo, n. sp.
Plate 13, fig. 12

Shell very small, elongate; length more than twice the height. Dorsal margin smoothly arched. Posterior two-thirds of the ventral margin straight, the anterior third also straight, but turning upward and forming a wide but distinct angle with the posterior portion of the margin. Extremities as seen in lateral view pointed, the posterior more elongate; the anterior blunter and shorter, with the point of greatest elongation located about one-third the height of the shell above the ventral margin.

Greatest height about one-third the length from the anterior end, at the point of curvature of the ventral margin; greatest convexity median. Overlap of the larger left valve inconspicuous, and almost imperceptible in lateral view. The overlap is greatest along the ventral margin, particularly in the median portion, and can be easily seen along the entire length of the shell when viewed ventrally. Dorsally the valves appear to meet evenly and without overlap except along the antero-dorsal slope, where a slight overlap of the left valve is evident. The valves are quite unequal in size, the left considerably the larger. The anterior extremity in ventral and dorsal view is somewhat sharper than the posterior, the shell narrowing more rapidly toward the anterior end. Surface smooth.

Length, 0.60 mm.; Height, 0.24 mm.; Thickness, 0.28 mm.

Locality.—Transcontinental, Blackstone-Slaughter No. 1. Depth, 1,365-75 feet.

ACRATIA MAGNA Delo, n. sp.
Plate 13, fig. 13

Shell of moderate size, conspicuously elongate. The general characters of the lateral profile are the same as those of *Acratia typica*,

[1] Harlton, Bruce H., "Pennsylvanian Ostracoda from Menard County, Texas", Univ. of Texas Bull., No. 2901, pl. 4, fig. 5.
[2] Knight, J. Brookes, "Some Pennsylvanian Ostracodes from the Henrietta Formation of Eastern Missouri", Journ. of Pal., vol. 2, no. 4, pl. 44, figs. 1 a-c.

although the proportions of *A. magna* show a much greater posterior elongation and larger size. As far as can be seen from the broken edges of the valves, the character of the overlap of the left valve is identical in both species, and it is also much the larger.

Length, 1.26 mm.; Height, 0.52 mm.; Thickness, 0.56 mm.

Locality.—So. Crude Oil Pur. Co., Allison No. 1. Depth, 600-606 feet.

Superfamily CYTHERACEA

Family CYTHERIDAE? Zenker

Genus KELLETTELLA, new genus

This genus bears little resemblance to any Carboniferous form known to the writer. It is characterized by a sub-oblong lateral profile, the anterior and posterior height about the same. The valves are subequal, the right indistinctly overlapping the left. The large ventro-lateral ridges are characteristic.

The genotype is *Kellettella naviculata* Delo, n. sp.

The genus is tentatively placed in the Cytheridae until further study of more material can determine its true taxanomic position.

Kellettella is named for Miss Betty Kellett of Tulsa, Oklahoma.

KELLETTELLA NAVICULATA Delo, n. sp.
Plate 13, fig. 14

Shell small, elongate; lateral profile sub-oblong. Dorsal margin almost straight, with slight median convexity; extending almost the entire length of the shell. Extremities subequal, the posterior very slightly higher; evenly and moderately curved. Cardinal angles obtuse, distinct, subequal. Ventral margin straight, with rather abrupt regular upward curvature at the ends. Overlap of the right valve upon the left indistinct, most apparent in dorsal view at the ends of the hinge, the edges of the valves meeting evenly along the ventral margin. Valves are of almost equal size. Convexity of the shell moderate, greatest throughout the median portion.

The ventro-lateral portion of each valve bears a thick false keel which arises on either extremity at about the line of greatest elongation of the shell, and continues the entire length of the ventral margin. The keels are broader and more widely separated in the post-ventral portion. The surface of the valves is slightly flattened above the keels. Viewed dorsally the shell is very narrow at the extremities.

The hinge is depressed in a long narrow area with gently curving sides.

Length, 0.84 mm.; Height, 0.40 mm.; Thickness 0.36 mm.

Locality.—C. Cromwell, Winslow No. 1. Depth, 760-90 feet.

Family CYTHERELLIDAE Sars

Genus CYTHERELLA Jones

CYTHERELLA OVOIDIFORMIS Harlton

Plate 13, fig. 15

Cytherella ovoidiformis HARLTON, 1928, Journ. Pal., vol. 2, no. 2, p. 141, pl. 21, figs. 15 *a, b.* (Graham formation; Stephens County, Texas.)

Cytherella ovoidiformis HARLTON, 1929, Univ. of Texas Bull., No. 2901, p. 161, pl. 4, figs. 8 *a-c.* (Canyon; Menard County, Texas.)

Shell of medium size; lateral profile elliptical. Margins gently and evenly curved; extremities subequal, regular. Overlap of the right valve most prominent in median portion. Viewed dorsally, the shell is thickest near the posterior end, tapering regularly to the narrower anterior extremity. Right valve slightly the larger; surface smooth.

Length, 0.94 mm.; Height, 0.60 mm.; Thickness, 0.36 mm.

Locality.—C. Cromwell, Winslow No. 1. Depth, 380-90 feet.

This species is found widespread in the Carboniferous formations in Texas, and only slight variations have been noted among the forms from different horizons.

CYTHERELLA CONSTRICTA Delo, n. sp.

Plate 13, fig. 16

Cytherella benniei GIRTY, 1909, U. S. Geol. Survey Bull. 389, p. 116, pl. 8, figs. 7-9. (Yeso formation, Manzano group; San Andreas Mountains, New Mexico.)

Shell of medium size, rather elliptical. Although the median portion of both dorsal and ventral margins is broken, the curve near the extremities indicates a gentle median curvature. Extremities evenly rounded, the posterior slightly the higher. Overlap of the right valve upon the left present throughout, more prominent in median part; right valve slightly the larger.

An inconspicuous vertical sulcus is located about one-third the length from the posterior end, trending upward for about two-thirds the height of the shell. Almost immediately in front is another smaller and shorter sulcus extending downward from the dorsal margin. The sulci give the shell the suggestion of a band tied around it

about one-third from the posterior end in such a manner as to slightly inflate the posterior third. The depression of the surface is more evident on the left valve.

Length, 0.92 mm.; Height, 0.52 mm.; Thickness, 0.36 mm.

Locality.—Transcontinental, Blackstone-Slaughter No. 1. Depth, 1,365-75 feet.

Comparison with Jones, Kirkby and Brady's figures of *C. benniei* show that this form is not identical with their species. The sulci and elongate form differentiate it from any described species known to the writer.

A REVIEW OF THE GENUS ROUXIA

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Upon attempting to identify some California diatoms belonging to the genus *Rouxia* it became necessary to examine all of the existing literature on the group. Notes made during this inquiry may be useful to students in the future.

The genus dates from 1893 when it was established by Brun and Héribaud in a rare paper by the latter on the freshwater diatoms of Auvergne, France[1]. It was placed by its original founders, and also by Brun alone in 1893, in the Pseudoraphidiae of the tribe Tabellariae. This disposition seems to be incorrect and Van Heurck[2] in 1895 removed it to the Raphidieae where he associated it with *Berkeleya, Amphipleura, Reicheltia* and *Brebissonia.* When Cleve wrote his monumental work on naviculoid diatoms he evidently had not seen Héribaud's paper because the genus is not mentioned therein. Schütt[3] in 1896 used the name as a subgenus under *Amphipleura* and reproduced only the angulated, sigmoid form of Van Heurck's 1896 report. Karsten[4] in 1928 did the same except that he admitted the group to full generic rank. Taylor[5] in 1929 likewise recognized the genus, and gave it equal standing with *Vanheurckia, Brebissonia, Amphipleura,* etc. Probably the genus is treated in other general books on botany. The discovery of a representative of the group living in the Antarctic regions by Heiden and Kolbe[6] is extremely interesting and confirms similar observations pertaining to other genera

[1] Héribaud, Joseph, Les Diatomées d'Auvergne (1893), p. 156, pl. 1, figs. 12 a-c.
[2] Le Diatomiste, vol. 2, no. 21 (1895), p. 182; and Treatise on the Diatomaceae (1896), p. 244, fig. 45.
[3] Schütt, F., In Engler and Prantl, Pflanzenfam., Tl. 1, Abt. 1 b, 1896, p. 132, fig. 239.
[4] Karsten, G., In Engler, Pflanzenfam., Ed. 2, vol. 2, 1928, p. 281, fig. 376.
[5] Taylor, F. B., Notes on Diat., 1929, pp. 52, 120, 217.
[6] Heiden H., and Kolbe, R. W., Der Marinen Diatomeen der deutschen südpolar Expedition, 1901-1903; Deutsch. Südpolar Exp., 1901-1903, vol. 8, Bot., 1928, pp. 447-715, pls. 31-43.

(such as *Hemiaulus*) found only in Tertiary or older rocks in the northern hemisphere.

The various genera of the group to which *Rouxia* belongs may be arranged as follows in descending order from the true naviculoid form toward the Pseudoraphidieae which lack a trace of a central longitudinal bar or raphe but usually possess a blank line in that position. *Cistula, Stenoneis, Rhaphidodiscus, Brebissonia, Amphipleura, Reicheltia, Berkeleya, Rouxia.* According to this arrangement, *Rouxia* is the most degenerate of all, central and terminal nodules being absent and the raphe being reduced to two, short, isolated bars.

ROUXIA Brun and Héribaud

Rouxia BRUN and HÉRIBAUD, Diat. Auvergne, 1893, p. 156; dedicated to Maxine Roux.

Original description.—"The genus *Rouxia*, of the tribe Tabellariées, has the following characters:

"Valve oblong, fusiform with median line interrupted at the center (pseudoraphia) and forming thereby two short, rectilinear bars, placed end to end and distinctly separated from each other. Valve slightly asymmetrical, beaded. In side view a little sigmoid.

"The presence of the two little raphiae makes it difficult to exactly classify the genus *Rouxia* in the family of diatoms. The segmentation of the raphe resembles the genera *Brebissonia* and *Berkeleya;* but, on the other hand we have observed several times that in some of the Pseudoraphidieae especially *Eunotia, Peronia,* and *Actinella,* the terminal nodule is prolonged to form a short canal and a little mark; it is this analogy which has caused us to place this exotic genus in the same group." [Trans. G. D. H.]

All of the known species are considered below.

ROUXIA PERAGALLI Brun and Héribaud
Plate 14, figs. 1, 5

Rouxia peragalli BRUN and HÉRIBAUD, in HÉRIBAUD, Diat. d'Auvergne, 1893, p. 156, pl. 1, fig. 12 *a*, not *b* and *c;* type locality, Japan.—BRUN, Le Diatomiste, vol. 1, 1893, p. 177, pl. 24, fig. 2.—VAN HEURCK, Treatise, Diat., 1896, p. 244 (in part, not fig. 45).

Original description.—"Valve in face view, linear in the median region where it is sometimes slightly concave.

"The ends are attenuated, obtusely conical or roundly conical and ordinarily are slightly unequal. Two lines of beads surround each raphe. These two median lines of beads extend entirely to one extremity, ending in fine punctae; at the other end they terminate at

about the center of the terminal cone, [raphe bar] and this accentuates the asymmetry of the valve. The border portion, also with beads arranged singly or doubly. These marginal beads extend to the extremities, diminishing gradually in size. Length, 40μ to 75μ; width, 6μ to 7μ.

"Japan. Fossile: Deposit at Abokiri and in limestone at Sendai. This species is dedicated to M. Maurice Peragallo in recognition of the considerable work which he has done on our fossil diatoms."

Photographic copies of the four original figures are reproduced herewith and among them two species appear to be represented. Brun in 1893 reproduced a photograph of what appears to be the smaller, ovate specimen of the original set of figures and he then accredited the name to himself alone. The Auvergne paper has date preference, however, because Brun gave a reference to it in his 1893 notice. The species name should therefore be written "*Rouxia peragalli* Brun and Héribaud" although it is probable that Brun alone studied the material; his great work on Japanese fossil species is well known. Brun's 1893 figure is likewise reproduced herewith. In this paper he did not give a formal description and mentioned no locality but gave some notes on relationship as stated above. Since the first figure of Héribaud and the only one of Brun is the small ovate form it seems obvious that this was the one to which Brun associated the name *peragalli*. The selection thus made, automatically causes the ovate form to become the type of the genus *Rouxia*.

The angular form (figs. 12 *b*, *c* of Brun and Héribaud) probably was not the most common in the material and it can hardly be considered to be the same as the ovate form. The latter is certainly flat; the photograph demonstrates this. The angular form, however, is sigmoid in edge view. These characters appear to be sufficiently important to warrant specific separation of the two forms.

Van Heurck did not reproduce the ovate form when be considered the genus in 1896 but did copy the sigmoid valvular view and the largest of the angular forms.

It is exceedingly doubtful if both the ovate and angular forms came from the same fossil deposit or the same horizon; and since two localities are mentioned in the original description we may venture to assume that one came from each. But whether the ovate form came from Abokiri or Sendai we have no means of knowing. Tempere and Peragallo did not list the species in their catalog of the diatoms of any place in Japan[7].

[7] Tempere, J., and Peragallo, H., Diat. du Monde Entier, Ed. 2 (1913), pp. 358-363.

The nude subspecific name, *elongata*, found in the list of "Santa Cruz, California", diatoms of Tempere and Peragallo cannot be accepted; the name itself is not sufficiently diagnostic to permit recognition of that which the authors observed. (See under *R. californica*.)

The errors committed in regard to the location of this last mentioned deposit call for some comment. Presumably Tempere received a sample of shale from the San Francisco Microscopical Society, or some one in California, labelled "Santa Cruz, Cal." or "Santa Inez, Cal." He transmitted a portion of the cleaned material to M. J. Brun and one or the other mistook the state to be Colorado. In Brun's first men-

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EXPLANATION OF PLATE 14

FIG. 1.—*Rouxia peragalli* Brun and Héribaud, ×1,000; photographic copy of original figure (pl. 1, fig. 12 *a*) in Héribaud, Diatomées d'Auvergne, 1893.

2.—*Rouxia yabei* Hanna, n. sp., ×1,000; photographic copy. This and fig. 3 were fig. 12 *b* on pl. 1 of Héribaud, Diatomées d'Auvergne, 1893, and were referred there to *R. peragalli*.

3.—*Rouxia yabei* Hanna, n. sp., ×1,000; photographic copy. This and fig. 2 were fig. 12 *b* on pl. 1 of Héribaud, Diatomées d'Auvergne, 1893, and were referred there to *R. peragalli*.

4.—*Rouxia yabei* Hanna, n. sp., ×1,000; photographic copy. This was fig. 12 *c* on pl. 1 of Héribaud, Diatomées d'Auvergne, 1893, and was referred there to *R. peragalli*.

5.—*Rouxia peragalli* Brun and Héribaud, ×900; photographic copy from Brun, Le Diatomiste, vol. 1, 1893, pl. 24, fig. 2.

6.—*Rouxia californica* M. Peragallo, ×1,000. Plesiotype (No. 3087, Calif. Acad. Sci.) from Lompoc, California; Miocene. Length, .0823 mm.; width, .0052 mm.; about 130 beads in .01 mm.

7.—*Rouxia californica* M. Peragallo, ×1,000. Plesiotype (No. 3088, Calif. Acad. Sci.) from Lompoc, California; Miocene. Length, .0876 mm.; width, .0056 mm.; about 130 beads in .01 mm.

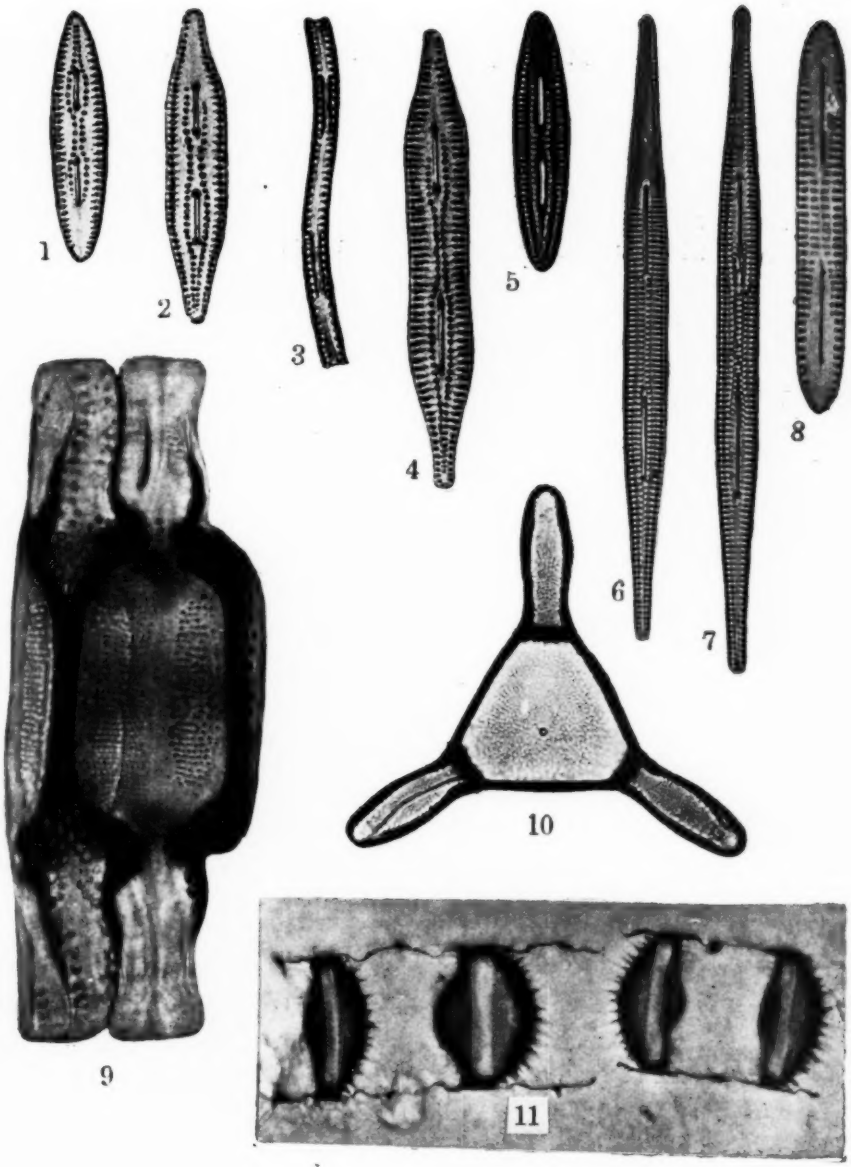
8.—*Rouxia antarctica* Heiden and Kolbe, ×1,000; photographic copy from Deutsch Südpolar Exp., 1901-1903, vol. 8, Bot. Die marine Diat., 1928, pl. 4 [34], fig. 90.

9.—*Lithodesmium cornigerum* Brun, ×1,500. Plesiotype (No. 3135, Calif. Acad. Sci.) from 4 miles west of Casmalia, California; Pliocene. Edge view of two frustules; length (from top to bottom on plate), .060 mm.

10.—*Lithodesmium cornigerum* Brun, ×840. Plesiotype (No. 3136, Calif. Acad. Sci.) from 4 miles west of Casmalia, California; Pliocene. Distance between tips of two arms, .0636 mm.

11.—*Omphalotheca*, sp., ×965. Plesiotype (No. 3137, Calif. Acad. Sci.) from 4 miles west of Casmalia, California; Pliocene. Edge view of four frustules in chain; diameter (from top to bottom on plate), .020 mm.

Magnifications are approximate.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tion of the deposit in print[8] he gave the locality as "Colorado". Later in the same journal[9] he described four new species from the deposit, the locality being given as "Santa Cruz, Colorado".

Tempere apparently suspected an error in locality because in the first edition of "Diatomées" [du Monde Entier] by him and Peragallo the name was changed to "Sta. Suez" and the locality was placed among other California localities, "Santa Barbara, San Fernando, San Bernardino", etc. In the tables accompanying this work the locality was again changed, this time to "Sta. Crux (not Suez), Cal., U. S. A."[10] In the second edition of this work the locality was changed back to "Santa Cruz, Colorado". The authors in listing 155 species and forms remarked upon the differences between the material and that of California; also they commented upon the occurrence of such a deposit in the interior of the continent. Obviously "Colorado" is an error.

A great deal of time has been spent in the vicinity of Santa Cruz, California, searching for material which would yield an assemblage similar to the forms in the lists cited. While diatomite has been found in many places in that immediate neighborhood none of it seems to fit. Even Santa Cruz Island has been investigated and the diatomite there was found to be of greater age than that which carries *Rouxia*. Eventually a portion of the Tempere sample was purchased in Paris and a careful study of this with the lists has convinced me that it is a mixture from more than one locality. The presence therein of Temblor, middle Miocene, distinctive species indicates that some of it may have come from Santa Cruz Island. Also, the presence of some characteristic Pliocene forms such as *Lithodesmium cornigerum* Brun, is equally convincing that part of the sample came from the vicinity of "Santa Ynez, California". This place is often spelled "Inez" and it is easy to understand how it might be construed as Suez". The confusion of "Cal." and "Col." is obvious. Enough is now known of the geological and geographical distribution of fossil diatoms in California to make the information here given seem reasonably certain.

[8] Brun, J., Notes sur quelques Diatomées miocenes, Le Diatomiste, vol. 2 (1895), p. 209.
[9] Op. cit., pp. 231, 239, 241.
[10] Tempère, J., and Peragallo, H., Diatomèes collection, 1889-1895, pp. 197, 8 [suppl.].

ROUXIA ANTARCTICA Heiden and Kolbe
Plate 14, fig. 8

Rouxia peragallii typica HEIDEN, in HEIDEN and KOLBE, Deutsch. Südpolar Exp., 1901-1903, vol. 8, Bot. Die marine Diat., 1928, p. 632.
Rouxia peragallii antarctica HEIDEN and KOLBE, Op. cit., p. 632, pl. 4 [34], fig. 90.

The forms found living by these authors were divided into two varieties as indicated above but a comparison with the original figures and dimensions of *peragalli* indicates that the Antarctic diatoms should be classed as a distinct species. The following shows the comparative measurements:

Length	Width	Striae in .01 mm.	
29-47μ	8-9.7μ	87-124	*typica*
34-55μ	6.5-9μ	87-124	*antarctica*
40-75μ	6-7μ	130[11]	*peragalli*

The shape and the wide separation of the raphe-bars are the most distinguishing features of *antarctica*. The form was found at three stations between 58° 26′ and 61° 58′ south latitude and 90° 22′ and 95° 8′ east longitude in depths ranging from 4,018 to 4,840 meters.

ROUXIA YABEI Hanna, n. sp.
Plate 14, figs. 2, 3, 4

Rouxia peragalli BRUN and HÉRIBAUD, in HÉRIBAUD, Diat. d'Auvergne, 1893, pl. 1, figs. 12 *b, c;* not fig. *a*, ovate form.—VAN HEURCK, Treat. Diat., 1896, p. 244, fig. 45.—SCHÜTT, in ENGLER and PRANTL, Pflanzenfam. Tl. 1, Abt. 1b, 1896, p. 132, fig. 231.—KARSTEN, in ENGLER, Pflanzenfam. Ed. 2, vol. 2, 1928, p. 281, fig. 376.

This name is used to differentiate the coarse angular form figured with the original description of *R. peragalli*. Because of its sigmoid shape in edge view and its angular outline it cannot well be considered to be the flat, ovate form which Brun and Héribaud first figured and the only one which Brun alone figured very shortly thereafter.

This ovate form is therefore chosen to represent the name *peragalli* and the angular form is named for Dr. H. Yabe, in recognition of his study of the paleontology of Japan.

The type locality is either "Abokiri" or "Sendai, Japan".

[11] Computed from Brun's photograph reproduced as fig. 5 herewith.

ROUXIA CALIFORNICA M. Peragallo
Plate 14, figs. 6, 7

Rouxia californica M. PERAGALLO, in TEMPERE and PERAGALLO, Diat. du Monde Entier, Ed. 2, 1910, p. 245; San Pedro, Calif.; [Miocene].

Rouxia californica var. *elongata* M. PERAGALLO, Op. cit., p. 245, San Pedro, Calif.; [Miocene].

Rouxia peragalli BRUN and HÉRIBAUD, TEMPERE and PERAGALLO, Diat. du Monde Entier, Ed. 2, 1909, p. 117; name listed from "Santa Cruz, Colorado;" [error for Santa Cruz or Santa Ynez, California].

Rouxia peragalli elongata TEMPERE and PERAGALLO, Diat. du Monde Entier, Ed. 2, 1909, p. 117; nomen nudum; name listed from "Santa Cruz, Colorado"; [error for Santa Cruz or Santa Ynez, California].

Original description.—"Differs from *R. peragalli* in that the entire surface is covered with indistinctly punctate striae. Length, 40μ; width, 7μ; 14 striae in 10μ". [Trans. G. D. H.] The variety is said to be: "More slender and elongate than the type. Length, 60μ; width, 5μ."

The names *californica* and *c. elongata* occur in a list of fossils from "San Pedro, California". No illustrations have heretofore been given and it would be difficult indeed to identify specimens from the descriptions alone. The associated diatoms, as listed, definitely prove the age of the deposit to be Miocene; apparently it is pelagic and is very likely equivalent to the pelagic strata at Lompoc. Some of Tempere's original material from San Pedro has recently been secured by the California Academy of Sciences and I am thereby able to validate the species with photographs and the following more extended description.

Valve elongate, tapering rather abruptly at each end from a rounded shoulder to a rounded point; sides straight; central nodule and true raphe absent; terminal nodules (or raphe-bars) distant from each end and consisting of elongated bars of silica; at each end of each bar there is a blunt rounded spine resembling the nodule of many *Actinocyclus;* around the border there is a single row of elongated beads; these beads are longest in the center of the valve and each has a constriction in the middle partially dividing it into two beads; in the center there are two longitudinal rows of rounded beads, the rows being close together in the center of the valve; they diverge to pass each side of the raphe-bars; at one end, these central rows cease at or just before the distal end of the bar; at the other end the rows continue to the end of the valve but diminish in size outwardly; in girdle view the valves are straight; central connecting zone very narrow; valves scarcely convex. Length, .0823 mm.; width, .0052 mm.; (plesiotype No. 3087).

Plesiotypes (Nos. 3087-3090; Mus. Calif. Acad. Sci.) from Lompoc, Santa Barbara County, California; Miocene.

The presence of a species of the genus *Rouxia* at Lompoc, California, among a definitely pelagic flora, indicates that the entire genus may have been pelagic. The form here being described is excessively abundant in some of the finer quality of the diatomite mined at Lompoc. In fact it is this with certain other elongated forms which causes the material of this deposit to have "superior qualities" for filtration. The long forms bridge the meshes of the filter cloths so that the circular and other efficacious forms will not pass.

The exact position in the Miocene section of the Lompoc layer which furnishes *Rouxia* has not been completely determined. I recently visited the deposit under the guidance of Mr. Henry Mulryan, resident geologist of the Johns-Manville Corporation, and it appeared from casual observation that the *Rouxia* zone was about 500 feet down from the top of the diatomite as there exposed. However, it cannot yet be stated positively that the "top" there is the stratigraphic top of the shale series as exposed at the type locality of the Monterey at Monterey, California.

R. californica is very constant in its characters and it is much less robust and more elongated than any of the other species.

I have detected the species in many samples from Lompoc. The first, handed to me by Dr. David Starr Jordan in 1923 was a part of the matrix of a fossil Sirenian which had been collected in the quarry of the Celite Company. The exact position in the quarry was not stated, except that it came from the upper portion[12].

Another sample was collected by Mr. G. W. Wallace of San Francisco, California, and came from a few hundred yards south of the first locality.

The species is very abundant in samples of that fine grade of filtering material sold by the Celite Company under the trade name "Supercel".

Two rather extensive lists of Lompoc diatoms have been published yet *Rouxia* does not appear in either of them[13].

The species *californica* is widely distributed in California Miocene shales, but appears to be confined in its vertical range to this very narrow zone exposed in the Lompoc quarries and its stratigraphic equivalent elsewhere. At one locality in the east end of the Purissima

[12] For a description of this Sirenian, Metaxytherium jordani see Kellogg, Carnegie Institution Washington, Publ. No. 348 (1925), pp. 57-70, pls. 9-11.

[13] Yermoloff, Nicholas, The diatomaceous earth of Lompoc, Santa Barbara County, California. Geol. Mag., vol. 57 (1920), pp. 271-277. Mann, Albert, The diatoms of the Lompoc Beds. In D. S. Jordan: The fish fauna of the California Tertiary. Stanford Univ. Publ. Univ. Ser. Biol. Sci., vol. 1, no. 4 (1921), pp. 292-298, pl. 56.

Hills, Santa Barbara County, about 75 per cent of the bulk of the material is composed of the species. I have found it sparingly in one of the layers exposed about nine miles east of Monterey in a position which may be 500 feet below the top of the shales in the type Monterey. It is very common in the pelagic layer exposed in the San Pedro Hills, Los Angeles County.

OBSERVATIONS ON LITHODESMIUM CORNIGERUM BRUN

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The diatom, *Lithodesmium cornigerum* Brun (see plate 14, figs. 9, 10), was described in 1896[1] from material which Brun had received from Tempere. A careful translation of the original description is as follows:

"Distance across middle of triangle, .07 mm. Surface of valve smooth or with only a few punctiform and sparse beads. Median spine long, very thin and fragile. Elongations of the triangle, long, cylindrical or slightly lanceolate. With homogeneous immersion it shows an internal rectilinear punctation, very easily seen on the connective side."

The original locality was given as "Santa Cruz de Colorado (Tempere) : assez fréquent". Much uncertainty has attended the published records of this important collecting station. In a previous paper I have explained this fully, noting at the same time that the sample from which the original lists were made was a mixture from more than one horizon. Part of this may have come from Santa Cruz or Santa Cruz Island, California and the remainder probably came from the Santa Maria district in the vicinity of Santa Ynez. "Colorado" is obviously an error.

The important matter at this time is the fact that this collection contained the very striking and distinct *Lithodesmium* in abundance. A very extended list of all of the diatoms from the original material appeared in 1909 by Tempere and Peragallo[2] and the *Lithodesmium* is contained therein.

The form has been found on at least three other occasions[3].

[1] Brun, J., Le Diatomiste, vol. 2, March, 1896, p. 239, pl. 24, figs. 15, 16, 17.
[2] Tempere, J., and Peragallo, H., Diat. du Monde Entier, Ed. 2, 1909, p. 117.
[3] Even as early as 1890 a crude outline drawing of what must have been this species was published by Wolle (Diat. N. America, 1890, pl. 105, fig. 12); the figure was called "Hydrosera triquetra Wallich" and the locality was given as "Slide, Santa Cruz, Cal."

(1) In 1907 Chas. S. Boyer found it in a slide sent to him by F. J. Keely who, in turn had received it from Messrs. Arnold and Anderson. These geologists had collected the sample from "soft shale of the uppermost portion of the Monterey, from the Pinal Property on the east side of Pine Canyon, on the north flank of Graciosa Ridge (Santa Barbara County, California)." The observations and identifications of Keely and Boyer were published in the Santa Maria report and with them two plates of figures[4]. On plate 19, fig. 1, in a general view of a strewn slide many *Lithodesmium cornigerum* may be seen. A much larger photograph of one of the specimens is shown on plate 20, fig. 1 *b*. Unfortunately none of these figures show more than the bare outlines of the fossils. It is significant to note that the locality from which this material came was considered to be near the top of the "Monterey Miocene"; it is now known that the shales there outcropping are Pliocene in age.

(2) The species has recently been found in a core sample taken from a well on the west side of the San Joaquin Valley, California. The data are as follows: "H. B. Porter, Well No. 1; Sec. 26, T. 28 S., R. 21 E., M. D. M., Kern County, California; depth 800-1,000 feet; Loc. No. 1304 Coll. California Acad. Sci.; J. B. Stevens. Coll." This material came from a stratum of diatomite which had well preserved and definitely identified Etchegoin Pliocene molluscan fossils both above and below.

(3) The species has also appeared in a piece of concretionary limestone I once took from an accumulation of tar-saturated Pliocene shale in the N. T. U. oil shale quarry, four miles west of Casmalia, Santa Barbara County, California. This rock is hard limestone which yielded an excellent assemblage of diatoms on proper treatment with acids. The locality is No. 1220 of the collection of the California Academy of Sciences. This lithodesmid is particularly abundant and like many other forms found in the sample it is preserved as it grew, in this case in chains, the frustules being attached as in life.

This permits a more thorough study of the species than Brun was able to make. In view of the fact that he had mountants of no higher index of refraction than Canada balsam or styrax it is not strange that he did not see and record the beautiful radial rows of fine beads on the disk, shown in my photograph. These are readily seen, even with dry objectives (4 mm.), when the diatoms are mounted in "Hyrax" with an index of refraction of about 1.80. Boyer's photo-

[4] For a discussion of the material and a list of the diatoms on the slide see: Arnold and Anderson, Geology and oil resources of the Santa Maria oil district, Santa Barbara County, California. U. S. Geol. Surv. Bull. No. 322, 1907, pp. 39-44, pls. 19, 20.

graph published by Arnold and Anderson probably was taken from a specimen which was mounted in Canada balsam because not the slightest trace of surface markings is shown.

Brun was also mistaken in saying that the central spine was long, thin and fragile. The manner in which the frustules grow, rim to rim, forbids such a spine; really it is very short. The girdle view is strongly suggestive of Van Heurck's genus *Bellerochea*[5] although the differences between that genus and *Lithodesmium* and *Ditylum* are not very pronounced.

The species appears to be an excellent marker of one of the zones of the Pliocene diatom-shale in California because it has been abundant on the four occasions when found. It cannot have a long vertical range in the strata and has not thus far been found in Monterey shale.

[5] See Peragallo, H. and M., Diat. Marine de France, pl. 95, 1901, figs. 4, 5.

THE GROWTH OF OMPHALOTHECA

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In treating of a lower Miocene form of this genus of diatoms recently[1] I gave some notes on the history of the group and referred to the fact that some students have considered the various species to be spore cases of certain species of *Chaetoceros, Hemiaulus* or other genera. It was stated at that time that such practice was hardly permissible as far as fossil forms are concerned because the alleged spore cases could rarely be associated definitely with a "parent" form.

It has recently been my good fortune to find a sample of rock in which *Omphalotheca* is abundant and in many instances the frustules are united as they were in life. (See plate 14, fig. 11.) These are found to grow in chains like *Stephanopyxis.* Although at least a hundred have been examined, in no case was a *Chaetoceros* individual associated with an *Omphalotheca.*

The manner in which the frustules are attached is peculiar and deserves some comment. The frustule is oval in outline (valve view) and from each end of each valve a thin delicate spine projects outwardly to join similar ones of neighboring frustules. Where these spines join there is an enlargement or thickening of the silica. The two valves are unlike in convexity. In some cases as many as 15 frustules were noted in a single chain.

Only one conclusion seems possible under such circumstances: This *Omphalotheca* is a distinct and valid species of diatom, having no intimate relation whatsoever to *Chaetoceros.*

The collection studied came from a piece of hard concretionary limestone found in a deposit of Pliocene tar-shale four miles west of Casmalia, Santa Barbara County, California. The deposit has been quarried extensively by the N. T. U. Company in operating an experimental plant for the extraction of shale oil.

Some of the other diatoms in the rock make it possible to fix the original stratigraphic position with considerable certainty. Particularly valuable in this connection is *Lithodesmium cornigerum* Brun, which is very abundant.

[1] Journ. Paleontology, vol. 1, no. 2, 1927, p. 117.

THE BENTON FAUNA OF EASTERN COLORADO AND KANSAS AND ITS RECORDED GEOLOGIC RANGE

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The writer has attempted to show in graphic form the geologic range of the various Benton invertebrates which have been found in Colorado east of the Front Range and in western Kansas. One hundred and four forms are listed. The data has been obtained from the literature, from the paleontologic collections of local institutions and the U. S. National Museum, and from field observations.

Most of the published information was obtained from Stanton.[1]

Additional data was obtained from the collections of the University of Colorado, Colorado College, and the Colorado School of Mines. Considerable unpublished information on material in the U. S. National Musuem was furnished by J. B. Reeside, Jr.

Acknowledgement is hereby gratefully given to Junius Henderson of the University of Colorado, Dr. F. M. Van Tuyl of the Colorado School of Mines, Professor I. A. Keyte of Colorado College and Dr. J. B. Reeside, Jr., who have very materially aided and encouraged the writer. Mr. Reeside not only contributed material but has read over and criticised the manuscript and proof. Henderson and Van Tuyl have also reviewed the subject matter. No pretense is made that this chart represents the final word on the subject as many areas in the region have been but slightly studied. It is hoped, however, that it may prove a useful working tool to geologists until additional information has been obtained to supplement it.

The species are arranged in alphabetical order on the chart. Forms which pass upward into the Niobrara are shown but purely Niobrara species are not given.

[1] T. S. Stanton. "The Colorado Formation and its Invertebrate Fauna", U. S. Geological Survey, Bulletin 106.

CHART SHOWING THE BENTON FAUNA OF EASTERN COLORADO AND KANSAS AND ITS RECORDED GEOLOGIC RANGE

NAME OF FOSSIL	BENTON	Graneros	Greenhorn	Carlile	Niobrara
		1	2	3	4
Acanthoceras coloradoense Henderson		—	X	—	—
Acanthoceras, n. sp. aff. coloradoense		—	X	—	—
Acanthoceras kanabenses Stanton		—	X	—	—
*Acanthoceras of group A. rhotomagense DeFrance		X	—	—	—
Actaeon propinquus Stanton		—	—	X	—
*Actaeon, sp.		X	—	—	—
Amauropsis bulbiformis Sowerby		—	—	X	—
Ammonite, n. genus aff. Puzosia		—	X	—	—
Anatina lineata Stanton		—	—	X	—
Anomia subquadrata Stanton		—	—	X	—
Arca, sp.		X	—	—	—
Avicula gastrodes Meek		—	—	X	—
Baculites gracilis Shumard		—	X	—	—
Belemnitella baculus Logan		—	X	—	—
Callista tenuis Hall and Meek		—	—	X	—
*Callista, sp.		X	—	—	—
Cancellaria malachitensis Stanton		—	—	X	—
Cardium pauperculum Meek		—	—	X	—
Cassidulus stantoni Clark		—	—	X	—
Cinulia, sp.		X	—	—	—
Coilopoceras novimexicanum Hyatt		X	—	—	—
Corbula kanabensis Stanton		—	X	—	—
Corbula nematophora Meek		X	X	X	X
*Dentalium, sp.		X	—	—	—
Donax cuneata Stanton		—	X	—	—
Donax oblonga Stanton		—	X	—	—
Exogyra columbella Meek		X	—	—	—
Exogyra laeviuscula Roemer		—	X	—	—
Exogyra suborbiculata Lamarck		—	—	X	—
Fasciolaria utahensis Meek		—	—	X	—
Fusus venenatus Stanton		—	—	X	—
Gervillia propleura Meek		—	—	X	—

Name of Fossil	Benton	Graneros	Greenhorn	Carlile	Niobrara
		1	2	3	4
Globigerina, sp.		—	X	—	—
Gryphaea newberryi Stanton		X	—	—	—
Gyrodes conradi Meek		—	—	X	—
Gyrodes depressa Meek		—	—	X	—
Haminea truncata Stanton		—	—	X	—
Heliococeras corrugatum Stanton		—	X	—	—
Helicoceras pariense Stanton		—	X	—	—
*Inoceramus aff. I. belvuensis Reeside		X	—	—	—
Inoceramus dimidius White		—	—	X	—
Inoceramus fragilis Hall and Meek		—	—	X	—
Inoceramus gilberti White		—	—	X	—
Inoceramus labiatus Schlotheim		—	X	—	—
Inoceramus labiatus var.		—	X	—	—
Inoceramus subconvexus Logan		—	X	—	—
*Leda, sp.		X	—	—	—
Liopistha concentrica Stanton		—	—	X	—
Lucina juvenis Stanton		—	—	X	—
*Lucina, sp.		X	—	—	—
Mactra emmonsi Meek		—	—	X	—
Mactra huerfanensis Stanton		—	—	X	—
*Mammites, sp.		X	—	—	—
*Mammites, an unnamed species		—	X	—	—
Mesostoma occidentalis Stanton		—	—	X	—
*Mesostoma, sp.		X	—	—	—
Metoicoceras whitei Hyatt		—	X	—	—
Modolia multilinigera Meek		—	X	—	—
*Nautilus, sp.		X	—	—	—
Ostrea lugubris Conrad		—	—	X	—
Ostrea malachitensis Stanton		—	—	X	—
Ostrea larva		—	—	X	X
Ostrea alta		—	X	—	—
Ostrea congesta Conrad		—	X	X	X
Ostrea soleniscus Meek		X	—	—	X
Ostrea, sp.?		—	X	—	—
*Pecten, sp.		X	—	—	—

Name of Fossil	Benton 1	Graneros 2	Greenhorn 3	Carlile 4	Niobrara
Pharella pealei Meek	—	X	—	—	
Pholadomya coloradoensis Stanton	—	—	X	—	
Pholadomya papyracea Meek and Hayden	—	X	—	—	
Pinna petrina White	—	—	X	—	
Placenticeras pseudoplacenta	—	—	X	—	
Prionocyclus macombi Meek	—	—	X	—	
Prionocyclus wyomingensis Meek	—	—	X	—	
Prionotropis hyatti Stanton	—	—	X	—	
Prionotropis woolgari Mantell	—	—	X	—	
? Prionotropis loevianus White	—	X	—	—	
Pugnellus fusiformis Meek	—	—	X	—	
Pyropsis coloradoensis Stanton	—	—	X	—	
Radiclites, sp.?	—	X	—	—	
Scaphites warrenii Meek and Hayden	—	—	X	—	
Serpula plana Logan	—	—	X	—	
Siliaua huerfanensis Stanton	—	—	X	—	
Solemya obscura Stanton	—	—	X	—	
°Stenonia, sp.	—	X	—	—	
Tapes cyprimeriformis Stanton	—	—	X	—	
Tellina whitei Stanton	—	—	X	—	
Textularia ? sp.?	—	X	X	X	
Thomasites (3 unnamed sp.)	—	X	—	—	
Trigonarca obliqua Meek	—	—	X	—	
Tritonidea huerfanensis Stanton	—	—	X	—	
*Turrilites, sp.	X	—	—	—	
*Turritella, sp.	X	—	—	—	
Turritella whitei Stanton	—	X	X	X	
Veniella mortoni Meek and Hayden	X	X	X	—	
Volutoderma ambigua Stanton	—	—	X	—	
Volutoderma dalli Stanton	—	—	X	—	
Volutoderma gracilis Stanton	—	—	X	—	
Volutoderma placatula Dall	—	—	X	—	
Volutoderma willistonii Logan	—	—	X	—	
Xenophora simpsoni Stanton	—	—	X	—	
Yoldia subelliptica Stanton	—	—	X	—	

* Undescribed species in U. S. National Museum collections.
° Echnoid collected by the writer now being described by J. B. Reeside, Jr.

ABSTRACTS AND REVIEWS OF RECENT PALEONTOLOGIC LITERATURE

Abrard, R. Etude comparative de *Nummulites gizehensis* Forskål et de *N. javanus* Verbeek: C. R. S. des Seances de la Soc. Geol. de France. 7, 89-91, 1928.

One of the nummulitid foraminiferal species of the Dutch East Indies of upper mid-Eocene age (Lutetian), is very closely related and probably descended from a well known wide spread Mediterranean form. This type of shell thus ranges from western Africa to Japan. R. C. M.

Abrard, R. L'Eocene du Cheringoma (Mozambique): C. R. S. des Seances de la Soc. Geol. de France. 7, 91-92, 1928.

Collections of fossils, mainly large foraminifera, from Mozambique indicate three horizons of upper Eocene age. R. C. M.

Abrard, R. Les nummulites operculiformes, stades primitifs et de degenerescence: Bull. Mus. nationale d'Hist. naturelle: vol. 34, no. 2: 183-184, Feb., 1928.

Discusses structural significance of characters of *Nummulites* in the upper Eocene. R. C. M.

Abrard, R. Les Foraminifères dans le Bartonien du bassin de Paris: Bull. Mus. nationale d'Hist. naturelle: vol. 34, no. 3: 233, Mar., 1928.

Notes the occurrence of numerous small foraminifera in the uppermost Eocene of the Paris basin. R. C. M.

Alexander, Charles Ivan. Ostracoda of the Cretaceous of North Texas: Texas Univ., Bull., no. 2907: 137 pp., Feb. 15, 1929.

This paper summarizes previous work on the Cretaceous stratigraphy of Texas, and on Cretaceous ostracodes in general; briefly describes the various Texas formations and their ostracode content; and gives descriptions and figures of 90 species (56 new) and 3 varieties (1 new) of Texas Cretaceous ostracodes. These fossils are valuable horizon markers. R. C. M.

Anderson, F. M. Notes on Lower Tertiary deposits of Colombia and their molluscan and foraminiferal fauna: Proc. Cal. Acad. Sci., vol. 17, no. 1: 1-29, June 22, 1928.

Describes Eocene (4,500 ft.), Oligocene? (2,000 ft.) and Miocene (4,000 ft.) of

northern Colombia, including marine, estuarine and lacustrine deposits. Several new species of mollusks and a new species of *Nummulites*, mostly from Eocene beds are described and illustrated. R. C. M.

Berry, Willard. Larger Foraminifera of the Verdun formation of northwestern Peru: Johns Hopkins University Studies in Geology, no. 9: 166 pp., 1929.

Describes a surprising variety (70 species, all new) of orbitoid Foraminifera from the lower part of the Oligocene of western Peru, all belonging to the genus *Lepidocyclina ss.* The shells are much smaller than average measuring 0.5 to 3.0 mm. in diameter. Possible causes of the small size are considered at length but no definite conclusions are reached. R. C. M.

Cooke, C. W. New Vicksburg (Oligocene) mollusks from Mexico: Proc. U. S. Nat. Mus., vol. 73, art. 10: 1-11, 1928.

Describes 1 new genus and 18 new species of mollusks from the Alazan clay of northeastern Mexico. Comparison with deposits in the United States indicates correlation with the Mint Spring marl member of the Marianna limestone, of Oligocene age, rather than with upper Eocene beds as heretofore. R. C. M.

Cushman, J. A., and Church, C. C. Some Upper Cretaceous Foraminifera from near Coalinga, California: Cal. Acad. Sci., Proc. (4), vol. 18: 497-530, Oct., 1929.

An oil well sample from Cretaceous strata near Coalinga, California, contains numerous Foraminifera that are new to this region. The fauna belongs very high in the Cretaceous being approximately equivalent in age to the Navarro of Texas and Velasco of Mexico. Descriptions of 43 species (5 new) and of a new genus, *Silicosigmoilina*, are given. R. C. M.

Cushman, J. A., and Kellett, Betty. Recent Foraminifera from the west coast of South America: Proc. U. S. Nat. Mus., vol. 75, art. 25: 1-16, 1929.

The Foraminifera in bottom samples taken off the west coast of South America from Ecuador to Peru are described in this paper. There are 31 species (5 new). The Foraminifera of this region are distinctive but have been little known. R. C. M.

Decker, Charles E. The correlation of rocks by means of microscopic fossils: Oklahoma Acad. Sci. (Okla. Univ., Bull., n. s. no. 409), Proc. 7: 171-176, 1928.

A brief general account of the principles and objectives of micropaleontologic work, with description of the nature of foraminifera and ostracodes. R. C. M.

Díaz Lozano, Enrique. Los microorganismos fósiles y la geología del petróleo: Bol. Petr. 26 (4-5) : 397-400, Oct. and Nov., 1928.

A general discussion of the importance of micro-fossils in determining stratigraphic and structural relations in the Mexican oil fields. R. C. M.

Douvillé, H. L'Eocene inferieur au Nord-Ouest de l'Inde d'apres les travaux du major Davies: C. R. S. des Seances de la Soc. Geol. de France, 7: 92-95, 1928.

Describes nummulitid Foraminifera from India and western Europe, with notes on genera *Siderina* and *Dictyoconoides*. R. C. M.

Driver, Herschel L. Foraminiferal section along Adams Canyon, Ventura County, California: Am. Assoc. Petr. Geologists, Bull., vol. 12, no. 7: 753-756, July, 1928.

Describes micro-faunal character of very thick (about 14,000 feet) section of Pliocene strata in Ventura County, California, and presents chart showing graphically lithologic features and variation in fossil content of different zones. R. C. M.

Fenton, C. L. The stratigraphy and larger fossils of the Plattin formation in Ste. Genevieve county, Missouri: Amer. Midland Naturalist, vol. 11, no. 2: 86-96, March, 1928; and nos. 3-4: 125-143, May-July, 1928.

Offers a stratigraphic section and describes and figures many of the Plattin fossils. R. C. M.

Galloway, J. J., and Ryniker, Chas. Foraminifera from the Atoka formation of Oklahoma: Okla. Geol. Survey, Circular 21: 36 pp., 5 pls., Jan., 1930.

Describes 33 species (6 new) of Foraminifera, of which 13 are restricted so far as known to lower Pennsylvanian bed. One new genus, *Endothyranella*, is proposed. The authors call attention to the nature of the wall structure in these shells which is described as calcareous and fibrous mainly, rather than arenaceous. Fusulinids identified with Staff and Wedekind's genus, *Schubertella*, are for the first time, so far as the reviewer recalls, recognized in North America. R. C. M.

Girty, G. H. The fauna of the middle Boone near Batesville, Arkansas: U. S. Geol. Survey Prof. Paper 154-B: (9-12) 73-103, 1929.

Describes a fauna, mainly composed of brachiopods, that is tentatively regarded as Burlington or Keokuk but distinct from both. R. C. M.

Hanna, G. D. The age of the diatom-bearing shales at Malaga Cove, Los Angeles County, California: Am. Assoc. Petroleum Geologists, Bull., vol. 12, no. 11: 1109-1111, Nov., 1928.

Study of the diatoms in shale at Malaga Cove, Cal., indicates correlation with upper Monterey beds, of late Miocene age. The diatoms are believed to have accumulated in shallow water. R. C. M.

Harlton, Bruce H. Some Upper Mississippian (Fayetteville) and Lower Pennsylvanian (Wapanucka-Morrow) Ostracoda of Okla-

homa and Arkansas: Amer. Journ. Sci (5): 254-270, September, 1929.

This paper describes and illustrates 30 species (19 new) of upper Mississippian and lower Pennsylvanian ostracodes from Arkansas and Oklahoma. The genera, *Paraparchites* and *Healdia*, are redefined and the new genus, *Bassleria*, is described. The close of Mississippian time is marked by a distinct faunal break. R. C. M.

Holmes, G. B. A bibliography of the conodonts with descriptions of early Mississippian species: Proc. U. S. Nat. Mus. 72, art. 5: 1-38, 1928.

An important contribution to micropaleontology that contains complete references and illustrations of all published conodonts except those of three recently issued and available works. Conodonts are characteristic fossils of black shales like the Chattanooga, etc. R. C. M.

Israelsky, Merle C. Upper Cretaceous Ostracoda of Arkansas: Arkansas Geol. Survey, Bull. 2 (extract): 20 pp., 1929.

Describes and figures 24 new species of ostracodes with notation of their stratigraphic range and abundance. R. C. M.

Liebus, A. Die Tertiarformation in Albanien. Die Foraminifera: Paleontographica, 20 (2-6): 41-114, 1928.

Describes and figures 51 species (2 new) of Tertiary foraminifera from Albania. R. C. M.

Marshall, William B. New fossil land and fresh-water mollusks from the Reynosa formation of Texas: Proc. U. S. Nat. Mus. 76 (1), no. 2798: 6 pp., 1929.

Describes three new genera and four new species of terrestrial mollusks. On basis of these and teeth of extinct horse and rhinoceras the Reynosa formation is assigned to the Pliocene. R. C. M.

Moore, Raymond C. *Basslerina*, a new holliniform ostracode genus, with description of new Pennsylvanian species from Texas and Oklahoma: Denison Univ. Bull., 29 (2), Sci. Lab., J. 24: 99-113, April, 1929.

Defines characters of a group of Carboniferous ostracodes which are segregated in the new genus, *Basslerina*, and describes eight new species. R. C. M.

Reed, F. R. Cowper. New fossil phyllopoda from Brazil: Serv. Geol. e Miner. do Brazil., Boll. N. 34: (English and Portuguese) 17 pp., 1929.

Describes three species of *Estheria* and three of *Leaia* from red shales on the Iguassu River. These are believed to be of Permian age. W. V. H.

Roth, Robert. A revision of the ostracod genus *Kirkbya* and subgenus

Amphissites: Wagner Free Inst. Sci., Pub. 1: 1-56, 1929.

A valuable paper that analyses and redefines the generic characters of a group of reticulate ornamented ostracodes that is important as markers of stratigraphic horizons. Fifteen new species of Pennsylvanian age and one from the upper Mississippian of Oklahoma and Arkansas are described. R. C. M.

Roth, Robert. A comparative faunal chart of the Mississippian and Morrow formations of Oklahoma and Arkansas: Oklahoma Geol. Survey, Circular 18: 16 pp., Feb., 1929.

A tabulation of described invertebrate fossils of upper Mississippian and lower Pennsylvanian formations in Arkansas and Oklahoma with attempt to determine correlations on a percentage of common species basis. R. C. M.

Schenck, Hubert G. *Discocyclina* in California: San Diego Soc. Nat. Hist., Trans. 5 (14): 211-240, Feb. 27, 1929.

Shows the character and distribution of this genus of larger foraminifera which is restricted to Eocene rocks; redescribes the genotype and the two or three known California species, one of them new. R. C. M.

Sheppard, George. Notes on the Miocene of Ecuador: Am. Assoc. Petroleum Geologists, Bull., vol. 12, no. 6: 671-673, June, 1928.

Approximately 5,000 feet of loosely consolidated sands and clays with some harder beds and several prolific fossil zones are distinguished as Miocene. These strata cover a fairly large area but are lacking in parts of the region through non-deposition. The older Tertiary was deformed and beveled by erosion before Miocene sedimentation. R. C. M.

Ulrich, E. O. Ordovician trilobites of the family Telephidae and concerned stratigraphic correlations: Proc. U. S. Nat. Mus., vol. 76, art. 21: 1-101, pls. 1-8, Feb. 14, 1930.

Describes the structural characteristics of 3 genera (1 new) and 31 species (24 new) mostly belonging to *Telephus*. All are fossils of the Atlantic realm of Ordovician and earliest Silurian age, restricted in America to the eastern part of the Appalachian valley and eastern Canada, and in Europe to Ireland, Scotland, Scandinavia and Bohemia. A detailed discussion of the problem of intercontinental correlation and of differentiation of American Paleozoic faunas on the basis of geographic origin is a specially interesting and valuable part of the paper. A correlation table for the American and European Ordovician and early Silurian is presented. R. C. M.

Vanderpool, H. C. A preliminary study of the Trinity Group in Southwestern Arkansas, Southeastern Oklahoma, and Northern Texas: Am. Assoc. Petroleum Geologists, Bull., vol. 12, no. 11: 1069-1094, Nov., 1928.

A study of the character, subdivisions, stratigraphic relations and fossils of the Trinity (Lower Cretaceous) beds in Arkansas, Oklahoma and northern Texas. Sand at the top of the section in each area is called Paluxy but in places where limestone (Glen Rose and equivalents) is absent, distinction from the "basement

sands" is practically impossible. Limestones in Arkansas and Oklahoma are correlated with the Glen Rose of Texas and with upper Glen Rose of wells in Louisiana. A thick red beds series underlying the Glen Rose in northwestern Louisiana, and a still older shale and limestone series with Lower Cretaceous are described. Fossil zones and characteristic guide fossils are indicated. R. C. M.

Vaughan, Thomas Wayland. Descriptions of new species of Foraminifera of the genus *Discocyclina* from the Eocene of Mexico: Proc. U. S. Nat. Mus. 76 (3): 1-18, 1929.

Describes 9 species (8 new) belonging to the large orbitoid genus of foraminifera, *Discocyclina*, from Mexico. They range in age from lower to upper Eocene. R. C. M.

Warren, P. S. and Rutherford, R. L. Fossil zones in the Colorado shale of Alberta: Amer. Journ. Sci: 5th ser., no. 92: 129-136, Aug., 1928.

The Colorado beds of west central Alberta comprise a lower dark clay shale 1,000-1,500 feet, a middle sandstone 150-400 feet and an upper dark shale 2,000-2,300 feet. Faunal zones are distinguished that permit correlation with beds from Graneros to Telegraph Creek, inclusive, of the Great Plains region of the United States. Fossil lists and guide fossils noted. R. C. M.

Weller, J. Marvin. The Gastropod genus Yvania: Ill. Geol. Survey, Rept. of Investigations, no. 18: 1-38, 3 pls., 1929.

A study of one of the common and important types of pleurotomaroid shells in the Pennsylvanian strata. Nine species (5 new) are described and one new genus, *Hypselentoma*, is defined. R. C. M.

Wiedey, L. W. Notes on the Vaqueros and Temblor formations of the California Miocene with descriptions of new species: San Diego Soc. Nat. Hist., Trans., vol. 5, no. 10: 95-182, 1928.

Reviews briefly the stratigraphic character and relations of the lower and middle Miocene in southern California and describes 33 new species, all but one mollusks. R. C. M.

Franke, A. Die Foraminiferen der Aachener Kreide (the Foraminifera of the Aachen Cretaceous): Preus. Geol. Landesanstalt, Jahrb. 48: 667-698, 1928.

A revision of the monograph by Beissel-Holzapfel that appeared in 1891. Contains many changes of nomenclature following classification by Rhumbler and redescriptions. R. C. M.

Zalessky, M. D. Premières observations microscopiques sur le schiste bitumineux du volgien inférieur.—Soc. Geol. du Nord Ann. 51: pp. 65-104, pls. 2-6, 1926 [1927].

The paleontological portion of this paper contains descriptions of the following new genus- and species-names (heavy type) of foraminifera:

Calatharia perforata, n. g., n. sp., p. 87, pl. 3, fig. 8.

Orbulina **vesca**, n. sp., p. 87, pl. 3, fig. 4, pl. 5, fig. 6.
Orbulina **crustosa**, n. sp., p. 88, pl. 5, fig. 12.
Orbulina **echinata**, n. sp., p. 88, pl. 5, fig. 6.
Orbulina **punctata**, n. sp., p. 88, pl. 5, figs. 14, 15; [not Terquem, 1862].
Molnaria spinulata, n. g., n. sp., p. 89, pl. 3, fig. 2, pl. 5, fig. 13.
Ammodiscus **rosanovi**, n. sp., p. 89, pl. 4, fig. 7.
Lepista ornata, n. g., n. sp., p. 90, text fig. 1; [not *Lepista* Wall. Lepid., 1863].
Cristellaria **gracilis**, n. sp., p. 90, pl. 5, fig. 9; [not Kübler & Zwingli, 1886].
Pulvinulina **volgensis**, n. sp., p. 91, pl. 5, fig. 17.
Operculina **bella**, n. sp., p. 91, pl. 5, figs. 8, 9?.
Cerataria pulchella, n. g., n. sp., p. 92, pl. 5, fig. 11.
Epistominites formosulus, n. g., n. sp., p. 92, pl. 3, fig. 7.
Cochlidion alexandrae, n. g., n. sp., p. 92, pl. 2, figs. 6, 6 *a*; [not *Cochlidion* Hübner, Lepid., 1906].
Cochlea vsevolodi, n. g., n. sp., p. 93, pl. 2, fig. 5; [not *Cochlea* Linnaeus, Moll., 1740].
Cochlea **saprocolli**, n. sp., p. 93, pl. 2, fig. 13.
Cochlea, sp., p. 93, pl. 3, figs. 3, 9.
Pectinaria costata, n. g., n. sp., p. 94, pl. 3, fig. 11; [not *Pectinaria* Lamarck, Verm., 1812].
Nodosaria **retensoria**, n. sp., p. 94, pl. 5, fig. 4.
Textularia **undorskensis**, n. sp., p. 94, pl. 5, fig. 5.
Volutaria potoniei, n. g., n. sp., p. 95, pl. 2, figs. 2, 3, 4; [not *Volutarius* Dumeril, Moll., 1806].

In addition to the above, two new genera and species of plants are described: *Pediastrites kidstoni*, and *Oscillatoriites bertrandi;* the first being placed in the Chlorophyceae and the second in the Cyanophyceae.

The material is from Simbirsk, Russia from rocks placed in the Jurassic.

The illustrations are from drawings made from polished surfaces or thin sections and identification therefrom would appear to be very difficult if not entirely impossible. Five of the nine new genus-names proposed have already been used in zoological literature and are therefore not available for foraminifera. Also two of the new species names placed in old genera have previously been used in these same genera for other forms.

Attention is called to these matters because the title of the paper gives no hint that it contains paleontological data and it is therefore likely to be overlooked.

G. DALLAS HANNA.

RESEARCHES IN PALEONTOLOGY

Prof. T. E. Savage and E. R. Griffin are leaving the University of Illinois about June first for an extensive collecting trip into Permian, Triassic, and Jurassic formations which will take them to Texas, New Mexico, Utah, California, and British Columbia.

J. Marvin Weller of the Illinois Geological Survey has a paper in the April (1930) issue of Transactions of the Illinois Academy of Science on the "Occurrence of Platycrinus in Pennsylvanian strata of western Indiana".

J. W. Peoples, graduate student in the geological department of Northwestern University, has completed a paper on the stratigraphy and paleontology of the Middle Devonian of the Tennessee Central Basin.

J. Marvin Weller presented a paper and lantern slides at the May meeting of the Illinois Academy of Science on Pennsylvanian sponge spicules from western Illinois.

E. R. Pohl, Professor of Paleontology, Vanderbilt University, is engaged in a study of Devonian faunas of Tennessee.

W. S. Adkins has completed a paper on the echinoid genus *Macraster* to be published by the Bureau of Economic Geology, University of Texas.

W. M. Winton, Geological Department of Texas Christian University, has made several collecting trips into southwestern Colorado, Utah, and Arizona, to collect fossils from the Mancos shale and other Cretaceous formations of the western states. He has in preparation a paper comparing the faunas of the central and western Cretaceous.

W. S. Adkins of the Bureau of Economic Geology, University of Texas, has completed a paper on *Eoradiolites* and other rudistids of the Texas Cretaceous.

Dr. Walter Staub of the Department of Geology is in Mexico collecting Clypeasters and other fossils for the Museum of Berne. He plans to return to Switzerland in August.

Dr. E. Jablonski, geologist for Vacuum Oil Company, has sailed for Melbourne, Australia, to explore parts of southeastern Australia and to make collections of fossils.

Miss Jeanette Jones of the Geological Department of Northwestern University has under the direction of Dr. John Ball completed a paper on the fauna of the later Ordovician strata of the Green Bay region, Wisconsin.

A. C. Noé, Department of Geology, University of Chicago, has a paper in the April issue of the Transactions of the Illinois Academy of Science on "Correlation of Illinois Coal Seams with European Horizons".

The March 31st number of the Micropaleontology Bulletin issued by the Department of Paleontology, Leland Stanford Jr. University, contains seven short articles, amongst which the following are of general interest:

Notes on subsurface methods employed in parts of the San Joaquin Valley, by Wm. F. Barbat.

A method of subsurface correlation in the Los Angeles Basin, by W. D. Rankin.

Some foraminifera from the Elwood Field, Santa Barbara County, California, by W. M. Smith.

Subsurface methods of the Texas-Louisiana Gulf Coast, by M. M. Kornfield.

John W. Wells and F. L. Whitney, Department of Geology, University of Texas, are preparing a monograph on the corals of the Trinity Division of the Lower Cretaceous of central Texas.

L. W. Stephenson has published in the Proceedings of the U. S. National Museum a paper entitled "Two new Mollusks of the Genera *Ostrea* and *Exogyra* from the Austin Chalk, Texas".

R. W. Harris, Department of Geology, University of Oklahoma, has completed a paper on the ostracod fauna of the upper Simpson formation of Oklahoma.

G. Arthur Cooper, Department of Geology, Yale University, has an excellent article in the February and March numbers of the American Journal of Science on the stratigraphy of the Hamilton group of New York.

NOTES ON NEW PUBLICATIONS

PALEOBIOLOGICA—Vol. 1, 1928 (7 parts, 518 pages, 41 plates, 134 text figures); Vol. 2, 1929 (7 parts, 401 pages, 42 plates, 43 text figures). Emil Haim & Co., Leipzig and Vienna; or Max Weg, Leipzig. Subscription price, 74 marks per year.

This new publication on paleobiology has a large and renowned list of contributors and is edited by Prof. Othenio Abel of Vienna. Most of the articles are in German, but many are in English or French. The scope of the journal is paleozoology and paleobotany with special reference to researches on adaptation, paleogenetics, and phylogeny. Literature reviews will be included in volumes subsequent to the second. The first two volumes are especially rich in articles on fossil vertebrates. The following are some random titles from the invertebrate and general list.

Abel, O., Parasitic Balani on coral heads in the Mediterranean Miocene.

Bachofen-Echt, A., Life and death in the amber forests (colored plates of amber insects).

Bather, F. A., Paleobiological researches on the genus Edriocrinus.

Marr, J. E., A possible chronometric scale for the graptolite-bearing strata.

Nopcsa, Baron F., The genera of reptiles. (Complete synopsis of living and fossil reptiles.)

Pia, J., Adaptive forms in calcareous algae.

Richter, R., Psychic reactions in fossil animals.

Van Straelen, V., The eggs of fossil reptiles.

Yakovlev, N., On discontinuous evolution in the brachiopods and echinoderms and the irreversibility of evolution in the former.

Pfannenstiel, M., Organization and development of the Gryphaeas.

Deecke, W., On Jurassic sea urchins.

Karny, H., Remains of life in the mangrove formation in Java.

Glaessner, M., Exuviae of fossil crabs. (Shed skins are common fossils, and some have even been used as holotypes.)

Kautsky, Fritz, Biological studies on the hinge of Tapes.
Vigh, Julius, Mummified cat from Hungary.
Klaehn, Hans, *Echinocorys ovatus* shell with some grooves (caused, the author believes, by the teeth or jaws of some Cretaceous animal).
Klaehn, Hans, Significance of crinoids and starfishes for the recognition of direction and strength of currents.

W. S. ADKINS.

ZEITSCHRIFT FÜR INDUKTIVE ABSTAMMUNGS- UND VERERBUNGSLEHRE—This genetics journal includes in its annual bibliography a long section on paleontology, which should interest working and research paleontologists. W. S. ADKINS.

JAWORSKI, E., Eine Lias-Fauna aus Nordwest-Mexiko: Abh. schweiz. geol. Gesell., vol. 48, pp. 1-12, 1 plate, 1 map, 1929. These fossils collected by Messrs. Wellings and Kellar from Santa Rosa, Sonora, include a species each of the following genera: *Neithea, Lima, Plagiostoma, Alectryonia, Trigonia, Astarte, Myoconcha, Deroceras.* The general stratigraphy of this region has been described by Kellar in the Eclogae geologicae Helvetiae in 1928. W. S. ADKINS.

DOUVILLÉ, HENRI, Les Couches à *Cardita Beaumonti:* Geol. Survey India, n. s., vol. 10, Mem. No. 3, Calcutta, 1928. Thirty-four species of fossils are described and illustrated. The strata represented by these forms lie immediately above ammonite-bearing beds that mark the base of the Danian in India. The fauna is regarded by Douvillé as the oldest Eocene of that country. It is especially interesting since many forms resemble so closely species that occur in the upper Midway of the Gulf Coast, that comparison of the two faunas suggests strongly that the upper Midway may be correlated with the *Cardita beaumonti* zone of India and Persia. F. B. PLUMMER.

STRAUSZ, LASZLO, Geologische Fazieskunde: M. Kir. Földtani Intezet Evkönyve (Jahrb. k. ung. geol. Anstalt), vol. 28, Heft 2, pp. 75-272, 1928. The first seventy-five pages outline the general principles of recognition and correlation of geologic facies, true and false criteria for their identification, features common to a given facies association, composition of faunas, characteristics of deep-water deposits, and other important features in facies study. One particularly good section deals with algal, bryozoan, coral, and other reefs. The remainder of the book is devoted to an analytical outline of the facies of the Tertiary deposits in Austria, Hungary, the Balkans, northern

Italy, and adjacent regions. Fossil lists, including records of occurrence and habitat of foraminifera, are extensive. The book unfortunately lacks an index. W. S. ADKINS.

HEINE, FRIEDERICH, Die Inoceramen des mittelwestfälischen Emschers und unteren Untersenons: Abh. preuss. geol. Landesanst. (n. F.), Heft 120, 1929. An extensively illustrated text with detailed descriptions of new and old Emscher *Inocerami*. This is of particular value in relation to the partially contemporaneous Austin chalk.
W. S. ADKINS.

HEINZ, RUDOLPH, Beiträge zur Kenntnis der oberkretazischen Inoceramen: 21st Jahresber. neidersächs. geol. Vereins Hamburg, pts. 1-3; Mitt. mineral.-geol. Staatsinstituts Hamburg, pts. 4-9, 1928. Starting as type section with the *Inoceramus*-zonation of the Upper Cretaceous chalk quarries at Lüneburg (described by Heinz in 23rd Jahresheft naturwiss Ver. Fürstentum Lüneburg, and in the Hamburg Staatsinstitut, vol. 8, 1926), the author reviews in successive parts the genus in Europe, South America, Misol Archipelago, New Zealand, New Caledonia, Australia, and incidentally discusses some American species. Part 4 comprises an ambitious attempt to analyze the features of *Inoceramus* sculpture. The work is indispensable to any study of the genus. W. S. ADKINS.

JAWORSKI, E., Untersuchungen über den Abdruck der Mantelmuskulatur bei den Ostreiden und Chamiden und die sog. Cirrhenabdrücke: Neues Jahrb. f. Min., etc., Beil.-Bd. 59, Abt. B, pp. 327-356, pls. 20-24, 5 text figs., 1928. The peripheral crenulations on the shells of Ostreidae and rudistids are impressions of the mantle musculature, not of the cirri. Extensive anologies in detailed structure between oysters and rudistids are discussed. Photographs of preparations of mantle of Recent chamids and of the impressions on shells of Cretaceous species including *Exogyra texana*. W. S. ADKINS.

KLINGHARDT, F., Entwicklungsgleicheiten (Convergenzen) zwischen Austern und Rudisten und die Ursachen ihrer Entstehung: Neues Jahrb. f. Min., etc., Beil.-Bd. 62, Abt. B, pp. 509-521, pls. 31-33, 1929. Thirteen kinds of similarities are discussed, including body form, ribbing, adaptations of ligament, muscle attachment, septation of shell, and layers and mode of attachment of shell. Causes of similar adaptations are stated to be similar conditions, currents, exposure to force of waves, avoidance of suffocation by sediments, and competition for location. W. S. ADKINS.

KLINGHARDT, F., Ueber sehr frühe Entwicklungsstadien eines Rudisten; Neues Jahrb. f. Min., etc., Beil.-Bd. 60, Abt. B, pp. 173-187, pls. 15, 16, 1928. Baby rudistids of *Eoradiolites liratus* (Conrad) from the lower Cenomanian of Palestine are described. They range in size from 4 mm. upward. The young stage is coiled like *Apricardia*. Similar abundant material of the same genus is known from Texas. For comparison, a *Monopleura marcida* from Austin, with coiled early stage, is figured. W. S. ADKINS.

KLINGHARDT, F., Die stammesgeschichtliche Bedeutung, innere Organisation und Lebensweise von *Eoradiolites liratus* Conrad sp.: Palaeontographica, vol. 72, pp. 95-101, pls. 12-14, 1929. The young of this Lebanon radiolite is carefully figured and described. In the opinion of the author *Eoradiolites* instead of being a primitive rudistid is highly specialized, takes on its radiolite characters early, and has behind it a long radiolite phylogeny. W. S. ADKINS.

GUGENBERGER, ODOMAR, Über Suturumbildungen bei Ammoniten: Centr. f. Min., Jahrg., 1929, Abt. B, nos. 5, 6, pp. 161-171, 250-264, 1929. Transformations of the suture, particularly the splitting of the saddles with increasing individual age; evaluation of author's new observations in the light of theories of suture development, as elaborated by Branca, Pia, Wedekind, Salfeld, and others.
W. S. ADKINS.

STEINMANN, G., Beiträge zur Stammesgeschichte der Cephalopoden: Zeit. ind. Abs. Ver. Lehre, vol. 36, Hefte 3, 4, pp. 350-416, pls. 6, 7, 1925. In one of his last works, the late Prof. Steinmann reexamined the Recent cephalopods for their bearing on the phylogeny of ammonites in the light of recent theories. Initial development of cephalopod shell, shell structure, organization of ammonite, shell of Argonauta, ammonite-like characteristics of Octopods, mode of life of ammonites as deduced from the form and structure of fossilized remains, and other related subjects are discussed. W. S. ADKINS.

BRINKMANN, ROLAND, Statistisch-biostratigraphische Untersuchungen an mitteljurassischen Ammoniten über Artbegriff und Stammesentwicklung: Abh. Gesell. Wiss. Göttingen, math.-wiss. Kl., (n. f.), vol. 13, pt. 3, 249 pp., 5 pls., 56 text figs., 129 diagrams, 1929. Monographie der Gattung *Kosmoceras;* Abh. Gesell. Wiss. Göttingen, math.-phys. Kl. (n. f.), vol. 13, pt. 4, 124 pp., 1 pl., 1929. Statistisch-phylogenetische Untersuchungen an Ammoniten: Zeit. ind. Abs. Ver. Lehre, Suppl., vol. 1, pp. 496-513, 1927. Statistisch-

phylogenetische Untersuchungen: Forschungen und Fortschritte, vol. 6, pt. 9, pp. 121, 122, 1930. Over three thousand *Kosmoscerata* collected by centimeter levels above a datum stratum in new cuttings in the upper Dogger (middle Jurassic) clays at Petersborough, England, were submitted to an exhaustive statistical study and analysis, to discover what features amenable to measurement would afford an approach to quantitative treatment of individual variation, phylogenetic development, and other debated and difficult ammonite questions. The results are too complicated to summarize briefly. All students interested in ammonites and desirous of mastering the more exact modern treatment and technique in this subject will find these works suggestive and full of ideas. The monograph contains a systematic description of the material. W. S. ADKINS.

CUSHMAN, J. A., and VALENTINE, W. W., Shallow-water foraminifera from the Channel Islands of southern California: Contrib. Dept. Geol. Stanford Univ., vol. 1, no. 1, 1930. This paper describes a number of foraminifera from warm temperate waters 20 fathoms or less in depth. Some of the species considered are also present in the Tertiary rocks of California. One new genus, *Dyocibicides*, and several new species are described. STANFORD UNIVERSITY PRESS.

CUSHMAN, J. A., The foraminifera of the Atlantic Ocean: U. S. Nat. Mus., Bull. 104, pts. 6, 7, 1929, 1930. Part 6 describes and illustrates species and genera of the families, Miliolidae, Ophthalmidiidae, and Fischerinidae. In the introductory pages the author rearranges the species of the earlier parts according to the new classification. Part 7 describes and illustrates the species and genera of the families Nonionidae, Camerinidae, Peneroplidae, and Alveolinellidae. HELEN JEANNE PLUMMER.

IN MEMORIAM

DANIEL FRANKLIN HIGGINS

Daniel F. Higgins, Professor of Geology in Lincoln Memorial University, Harrogate, Tennessee, and an active member of the Society, died in Knoxville, Tennessee, March 21st, 1930.

In 1882 Mr. Higgins was born at Joliet, Illinois, where he spent most of his boyhood and completed his high school course. Before leaving high school he became interested in drafting and map construction and procured a position in the topographic branch of the U. S. Geological Survey in 1899. He worked at topographic mapping summers and during part of the year while attending school. In 1900 he entered the University of Illinois, and in 1906 he transferred to Northwestern University where he graduated in 1907. From 1907 to 1909 he worked as topographer and geologic assistant in the Alaskan Division of the U. S. Geological Survey in a party engaged in geologic reconnaissance under Dr. U. S. Grant. In 1909 he received a master's degree from Northwestern University.

In 1910 Mr. and Mrs. Higgins took up missionary work in Korea. In this same country he joined the Suan Mining Company in 1913 and worked as geologist and mining engineer. In 1914 he resigned to accept a position as geologist with Pearsons & Sons, Ltd., and was very active in geological explorations for that company in China, India, Arabia, and north Africa. In 1916 he enlisted in the British Army and for fourteen months was in charge of a company of Chinese coolies digging trenches along the western front in France.

In 1920 he returned to the United States and completed his residence work toward a doctor's degree at the University of Chicago. During 1925 and 1926 he accompanied Dr. J. H. Breasted to Egypt and was in charge of a party engaged in archeologic investigation. Upon his return to this country he took charge of the geologic work in the Rocky Mountain Division for The Texas Company with headquarters in Denver. When this office was closed in 1929 he returned to Northwestern University where he gave lectures in petroleum geology. In the fall of 1929 he went to Lincoln Memorial University as professor of geology and paleontology.

Mr. Higgins was married to Ethel Nichols Taylor in 1910, and throughout his career she has accompanied him and shared his adventures and trials as a genial companion and able assistant. Two daughters were born in Korea who with his wife survive him. Funeral services were held at Joliet, Illinois, March 23rd, 1930.

Mr. Higgins was a Fellow of the Royal Geological Society of London, Geological Society of America, American Association of Petroleum Geologists, American Institute of Mining and Metallurgical Engineers, American Chemical Society, and Society of Economic Paleontologists and Mineralogists. He was author of numerous articles in U. S. Geological Survey bulletins, Geographic Journal, Economic Geology, Bulletin of the Canadian Institute of Mining Engineers, Bulletin of Association of Petroleum Geologists, and others.

In the death of Mr. Daniel F. Higgins our Society has lost one of its most distinguished members, a man of almost unlimited breadth of interest and capacity for work, a great explorer, a keen observer, a lover of research, a man highly imbued with a missionary spirit to serve humanity and his beloved science of geology.

F. B. PLUMMER.

LITERATURE REVIEWS

BERRY, WILLARD, and KELLEY, LOUIS, The foraminifera of the Ripley formation on Coon Creek, Tennessee: Proceedings U. S. Nat. Mus., vol. 76, art. 19, pp. 1-20, pls. 1-3, 1929. This paper describes and illustrates 16 old species, 14 new species, 5 new varieties, and 2 undetermined species of foraminifera found in very fossiliferous sandy and glauconitic marl collected by Dr. Bruce Wade from the lower part of the Ripley formation where it outcrops on Coon Creek, McNairy County, Tennessee. Dr. Wade reported in his excellent monograph (Prof. Paper 137) on the larger fossils that the marl was devoid of foraminifera, but Dr. Berry has revealed a varied fauna of exquisite and delicate tests, a condition of preservation typical in Ripley strata in Mississippi and Alabama. The Brady classification has been employed in this systematic treatise.

A careful study of some of this same material in the Plummer laboratory shows that the form called *Cristellaria midwayensis* Plummer is clearly *C. navarroensis* Plummer. The very frequent *Bulimina* is very close to *B. pupoides* d'Orbigny and in no way similar to *B. quadrata* Plummer with its broad quadrate base, smooth to only very faintly depressed sutures between last two or three chambers, and aperture high on the septal face. *Bolivina plaita* Carsey is well developed in the Owl Creek member of the Ripley where it outcrops on Owl Creek, Mississippi, but the common species of this genus in the Coon Creek member is shorter and bears beadlike elevations on the inner margins of its chambers much like *B. gemma* Cushman. *Globigerina rugosa* Plummer is very frequent in the Coon Creek Ripley and is probably the form recorded as *G. cretacea* d'Orbigny. *Reophax coonensis* W. Berry and *Discorbis ripleyensis* W. Berry belong to the genera *Clavulina* and *Epistomina* (*Pulvinulina* of Brady) respectively. In addition to the species reported by Dr. Berry, *Ceratobulimina cretacea* Cushman and Harris, *Pullenia sphaeroides* (d'Orbigny), and *Arenobulimina presli* (Reuss) are frequent and well developed. A large *Gaudryina* is the most abundant of the species in this fauna. *Ammolagena*, sp., *Globigerinella*, sp., and *Guembelina*, sp., are rather rare forms. HELEN JEANNE PLUMMER.

GALLOWAY, J. J., and RYNIKER, CHARLES, Foraminifera from the Atoka formation of Oklahoma: Okla. Geol. Survey, Circular 21, pp. 1-36, pls. 1-5, Jan., 1930. Of the 33 species described from the middle Atoka formation of lower Pennsylvanian age 6 are new. The authors stress the dominance of calcareous forms in Paleozoic foraminiferal faunas as typified by the group of species herein described and figured. They report as arenaceous only the forms of *Tolypammina* and *Nodsinella*, though the latter genus was originally described by Brady as calcareous. Three forms of the hyaline genus *Spirillina* and one of *Tuberitina* comprise the only representatives of this great group. The imperforate group is represented by 9 species of the genera *Agathammina*, *Ammonema*, *Bullopora*,

and *Ammovertella*, though this last-named genus is offered as the name for probable worm tubes instead of foraminiferal tests. The fibrous or granular calcareous group comprises 16 species of the genera *Endothyra*, *Endothyranella*, *Orobias*, *Globivalvulina*, *Tetrataxis*, *Paleotextularia*, *Deckerella*, *Stafella*, *Schubertella*, and *Fusulinella*. Galloway and Harlton have included in this publication their description of a new genus closely related to *Endothyra* and called *Endothyranella*, a multiform test characterized by the endothyrine coil in its early development followed by a rectilinear series of chambers in full maturity.

HELEN JEANNE PLUMMER.

FOURTH ANNUAL MEETING OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

The fourth annual meeting of the Society of Economic Paleontologists and Mineralogists was held at New Orleans, Louisiana, on Thursday and Friday, March 20-21, 1930. Twenty-eight papers were presented, the largest number ever read at a meeting of the Society. Of these papers, thirteen dealt with microscopic fossils, ten with the larger fossils, two with climatology, two with stratigraphy and one with ancient man. A list of the titles is included at the end of this report.

A business meeting of the Society was held Friday afternoon, March 21. The usual reports by the President and Secretary-Treasurer were read and approved and are published in this number of the JOURNAL.

At the close of the business meeting the following officers were elected to serve during 1930-1931:

J. A. Cushman, President
C. C. Church, Vice-President
Gayle Scott, Secretary-Treasurer
R. C. Moore, Editor

These officers, together with the retiring president, M. A. Hanna, constitute the excutive committee for the coming year.

The following program was presented:

1.—Relative Abundance of Species of Foraminifera at Type Localities of Byram Marl and Red Bluff Clay.
Henry V. Howe, Baton Rouge, Louisiana.

2.—Fossil Zonation in Fredericksburg and Washita Divisions of Texas Comanche.
W. S. Adkins, Austin, Texas.

3.—Tertiary Climates and Correlation.
Ralph W. Chaney, Berkeley, California.

4.—Corals of Trinity Division of Cretaceous of Central Texas.
John W. Wells and F. L. Whitney, Austin, Texas.

5.—Some Upper Carboniferous Foraminifera from the Shale Basin of Western Texas.
David M. Delo, Saint Louis, Missouri.

6.—Tetraloculina: A New Genus of Foraminifera from Santa Barbara, California.
John Daniel Gilboe, Bakersfield, California.

7.—Pennsylvanian Climates and Paleontology.
Albert W. Giles, Fayetteville, Arkansas.

8.—An American Record of Genus Orbitoides, Orbitoides palmeri, n. sp., from Cuba.
Donald W. Gravell, Houston, Texas.

9.—Zonation of Permian and Pennsylvanian Systems of North-Central Texas by Means of Fossil Cephalopods.
F. B. Plummer, Austin, Texas, and Gayle Scott, Fort Worth, Texas.

10.—Review of the Genus Rouxia.
G. Dallas Hanna, San Francisco, California.

11.—Ostracod Fauna of Bromide or Upper Simpson Formation of Oklahoma.
R. W. Harris, Norman, Oklahoma.

12.—Range of Niobrara and Benton Fossils in Colorado and Adjacent Areas.
J. Harlan Johnson, Golden, Colorado.

13.—Geologically Ancient Man in America.
Harold J. Cook, Agate, Nebraska.

14.—Distinctive New Species of Foraminifera from Oligocene of Mississippi.
Henry V. Howe, Baton Rouge, Louisiana.

15.—Recent Littoral Foraminifera of Texas and Louisiana.
Moses M. Kornfeld, Stanford University, California.

16.—Cephalopod Fauna of Admiral Formation of Wichita Group of North-Central Texas.
F. B. Plummer, Austin, Texas, and Gayle Scott, Fort Worth, Texas.

17.—Some Pelecypods of Glen Rose Formation.
Minette Lillian Ries and F. L. Whitney, Austin, Texas.

18.—Arenaceous Foraminifera from Ordovician and Silurian Limestones of Oklahoma.
W. L. Moreman, Lawrence, Kansas.

19.—Regional Extent of Marmaton and Cherokee.
Robert Roth, Bartlesville, Oklahoma.

20.—New Pelecypods from Glen Rose Formation of Central Texas.
F. L. Whitney, Austin, Texas.

21.—A Burrow? from Mount Selman Formation.
F. L. Whitney, Austin, Texas.

22.—The Genus Bolivinella in the Oligocene of Mississippi.
Henry V. Howe, Baton Rouge, Louisiana.

23.—Cephalopod Fauna of Caddo Creek Formation of Canyon Group.
Gayle Scott, Fort Worth, Texas, and F. B. Plummer, Austin, Texas.

24.—Fauna of Travis Peak Formation of Central Texas.
F. L. Whitney and Robert H. Cuyler, Austin, Texas.

25.—Some Calcareous Algae from Comanche of Texas.
F. L. Whitney and Marion I. Whitney, Austin, Texas.

26.—Petrographic Characteristics of Oklahoma Red Beds.
Maria Spencer, Norman, Oklahoma.

27.—Pennsylvanian Bryozoa.
Raymond C. Moore, Lawrence, Kansas.

28.—The Fauna of Three New Members of the Upper Eocene in the Gulf Coast of Texas.
Eli T. Monsour.

REPORT OF THE PRESIDENT

MARCH 21, 1930

The past year has been a very successful one in the history of our Society. The membership, both active and associate, has had a healthy growth. The JOURNAL OF PALEONTOLOGY has been kept at the high standard at which it was first issued. The fall meeting held at the University of Texas, Austin, Texas, November 16, 17, and 18, was an excellent, well attended meeting. These annual fall meetings have become one of the important functions of the Society. The Executive Council of the Society, all the members of which are members of the Paleontological Society, met with the Executive Council of the Paleontological Society in Washington during the Christmas Holidays to consider closer co-operation in the publication of paleontological papers. No definite action could be taken at the time.

The president was authorized through action of the Executive Council to appoint several committees.

1. "The president appoint a committee to carry to completion a project of publication of a series of concise volumes on the Stratigraphic Paleontology of North America and to be published by the Society as rapidly as completed."

The persons appointed on this committee were:

Raymond C. Moore, Chairman
John B. Reeside, Jr.
F. B. Plummer
Joseph A. Cushman
G. Dallas Hanna
Marcus A. Hanna

2. "The president appoint a research committee of five or more members of the Society who shall consider and make recommendations on specific projects which the Society can foster."

The persons appointed on this committee were:

W. S. Adkins, Chairman (3 years)
Robert Roth (1 year)
Stanley G. Wissler (1 year)
Bruce H. Harlton (2 years)
Merle C. Israelsky (2 years)
N. L. Thomas (2 years)
Charles Ryniker (3 years)
C. C. Church (3 years)

3. "The president appoint a committee to investigate and undertake to prepare and distribute cards of North American invertebrate species of fossils."

The persons appointed on this committee were:

F. B. Plummer, Chairman
John B. Reeside, Jr.
Joseph A. Cushman
G. Dallas Hanna
Raymond C. Moore
Marcus A. Hanna

Through unanimous approval the Executive Council authorized the president to submit to the Society at the regular Business Meeting the names of the following distinguished geologists to be considered for Honorary Membership in the Society:

Dr. Carlos Burckhardt
Prof. Charles Schuchert
Prof. J. Perrin Smith
Prof. J. A. Udden

(These names were unanimously approved by the Society, and the Secretary was instructed to notify each of the action of the Society.)

The Executive Council passed the following motion:

"With the approval of the Society the president shall appoint a committee to investigate the establishment of an international paleontological union for the purpose of fostering interchange of knowledge and material among the paleontologists of the world."

(The motion was passed unanimously by the Society at the regular business meeting.)

The following petition has been presented to the Executive Committee of the American Association of Petroleum Geologists:

PETITION

Under authorization of the Annual Meeting of the Society of Economic Paleontologists and Mineralogists in Fort Worth, Texas, March, 1929, and in conformance with provisions of the Constitution of the American Association of Petroleum Geologists, petition is presented to designate the Society of Economic Paleontologists and Mineralogists as a Technical Section or Division of the American Association of Petroleum Geologists.

Provided: It is the understanding of the Executive Council of the Society of Economic Paleontologists and Mineralogists that acceptance of this petition by the American Association of Petroleum Geologists involves acceptance of the Constitution and By-laws of the Society of Economic Paleontologists and Mineralogists.

Signed MARCUS A. HANNA,
JOHN B. REESIDE, JR.,
RAYMOND C. MOORE.

New Orleans, La., March 18, 1930.

The president as chairman of the program committee for the New Orleans meeting wishes to extend appreciation to all those who so kindly assisted in making the meeting a success.

MARCUS A. HANNA.

REPORT OF SECRETARY-TREASURER

MARCH 15, 1930

The membership of the Society of Economic Paleontologists and Mineralogists on March 1, 1930, numbered 219 active members and 35 associate members. During the past year 33 new active members and 17 associate members have been elected.

The work of the Secretary has been directed to increasing the revenue of the Society through obtaining new subscriptions and new advertising for the JOURNAL OF PALEONTOLOGY. Three thousand circular letters illustrating and describing the JOURNAL have been distributed to libraries and paleontologists in this country and abroad. About 500 letters and circulars have been sent to prospective advertisers soliciting business. The total paid subscription list of the JOURNAL OF PALEONTOLOGY, Volume III, amounts to 620. The total advertising amounts to 7½ pages yielding $541.90 of revenue. One page advertising the publications of the American Association of Petroleum Geologists is an exchange for an advertisement of the JOURNAL OF PALEONTOLOGY printed in the Bulletin.

A bibliography concerning fish otoliths compiled by Mr. Robert Campbell has been mimeographed and distributed to members of the Society as Special Publication No. 1. The cost of mimeographing such data is small in comparison with its usefulness; and it is hoped that other bibliographies may be distributed in the future.

At the invitation of the members of the Department of Geology and the Bureau of Economic Geology at the University of Texas, the Society held a very successful fall meeting at Austin, Texas, Nov. 16, 17, 18th. Over one hundred geologists attended. A complete report of the meeting was published in the December number of the JOURNAL.

The Pacific Coast section and Fort Worth section of the Society have continued active during the year. Interesting meetings have been held monthly during the fall and winter at Los Angeles and Fort Worth. It is hoped that during 1930 other sections may be organized.

The printing of the JOURNAL OF PALEONTOLOGY during the past year was let to A. H. Willis of Bridgewater, Mass. The proximity of the printer to Dr. Cushman has necessitated this arrangement, since it facilitated the handling of manuscripts and supervision of the styling and handling of printed copy of articles to be published. Altogether 440 pages and 44 plates have been printed in Volume III of the JOURNAL OF PALEONTOLOGY at a total cost of $3,906.

The present financial status of the Society is quite satisfactory as shown by the following statement:

FINANCIAL STATEMENT AS OF MARCH 1, 1930

RECEIPTS

Balance from March 15, 1929	$3,489.94	
Donations toward publication	1,215.04	
Subscriptions	2,946.83	
Membership dues	881.25	
Advertising	341.90	
Interest on bonds	124.57	
Total receipts		$8,999.53

DISBURSEMENTS

Secretarial and clerical work	$274.25		
Editorial work	240.00		
Postage and express	382.43		
Printed forms, stationery and supplies	323.96		
Pennsylvania R. R. Bonds	2,092.11		
		$3,312.75	
Printing of JOURNAL OF PALEONTOLOGY:			
Volume III, No. 1	$1,139.35		
Volume III, No. 2	1,108.91		
Volume III, No. 3	763.00		
Volume III, No. 4	895.40		
		3,906.66	
Total disbursements			$7,219.41
Balance on hand as shown by book			$1,780.12
Balance on hand as shown by bank			1,780.12

ASSETS

Pennsylvania R. R. Bonds (7% 1930) plus accrued interest	$2,058.30	
Stock of JOURNALS:		
Volume I	0.00	
Volume II (601 complete copies)	3,606.00	
Volume III (340 complete copies)	2,040.00	
		$7,704.30
Bills Collectable:		
Membership dues	$104.00	
Sales of JOURNALS (Subscriptions and copy sales)	244.00	
Advertising	427.50	
		775.50
Total assets		$8,479.80
GRAND TOTAL (assets plus cash balance)		$10,259.92

(Signed) F. B. PLUMMER, *Secretary-Treasurer.*
GENE ROSS, *Assistant to the Secretary.*

Audited:
F. W. ROLSHAUSEN
M. P. WHITE